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Turbo-Blowers for Blast-Furnace Plants

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Turbo-blowers are almost invariably chosen for new plants and for extensions in iron and steel works, and some reasons for their increasing use are discussed. Important factors in planning installations are considered, and particular reference is made to a recent installation at the Irlam Works of the Lancashire Steel Corporation.

TURBO-BLOWERS for use in conjunction with blast-furnaces may be either of the air-cooled or the water-cooled design, but the former is preferable for the following reasons :—

Due to the compression of the air in the blower, its temperature is raised to between 140° and 240° F. at the normal load, and to between 200° and 350° F. at maximum load, but a well-designed blower can readily deal with temperatures of this order. By using special means of air cooling, such as a water-cooled casing, the power input to the blower can be reduced, and, although the saving would amount to approximately 5%, this is counter-balanced by the amount of power required to drive the circulating water pumps for the cooling system. Furthermore, the use of cooling water complicates the construction of the turbo-blower, making the operation more difficult, and, in addition, increasing upkeep costs on account of impurities in the circulating water, causing the cooling spaces to become dirty and covered with scale, necessitating frequent cleaning. Moreover, the blast from the blowers has to be heated to at least about 1,000° F. before being passed into the blast-furnace, and, accordingly, the higher the temperature of the air coming from the blower, the less heating will be required before the air passes to the blast-furnace. For example, a furnace having a daily output of 1,000 metric tons would require a normal blast volume of approximately 80,000 cub. ft. per min. at a final blast pressure of 18·5 lb. per sq. in. gauge, and under these conditions, when the blower is of the uncooled pattern, the temperature of the air leaving the blower would be approximately 260° F., whereas with the blower cooled the temperature would be only approximately 160° F. The blast delivered from the uncooled blower is, therefore, preheated by approximately 100° F. before passing to the main air preheaters, giving a corresponding saving of gas in the preheaters.

From the above consideration it will be realised also the advantages to be gained in erecting the blowers as near to the air preheaters of the blast-furnace as possible, apart from the fact that this would also reduce to a minimum the pressure loss between the blower outlet and the blast-furnace air inlets.

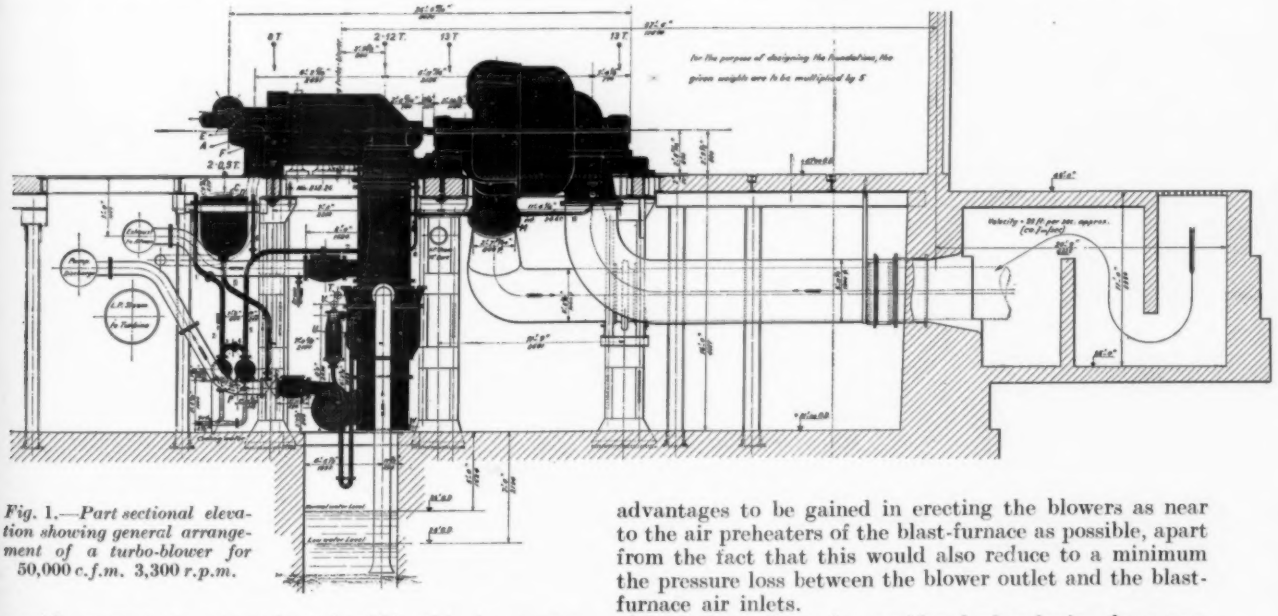


Fig. 1.—Part sectional elevation showing general arrangement of a turbo-blower for 50,000 c.f.m. 3,300 r.p.m.

A further point to be considered when laying down new blower plant is the installation of an air filter. Generally, with blowers having carefully made impellers of high-grade alloy steel, the provision of an air filter is not necessary, but in cases where the blowing plant is installed in the vicinity of coke-loading stages or the ore bins, or if the blowing plant is so placed that it is liable to suck in sand dust stirred up by wind, then the installation of an efficient air filter is to be strongly recommended. Should an air filter not be provided under such conditions, erosion of the impeller blades from the action of the sharp-cornered particles must be expected, and as a result of this wear the life of the machine is shortened.

Blast-furnace turbo-blowers can either be motor or steam turbine driven, but in modern blast-furnace plants,

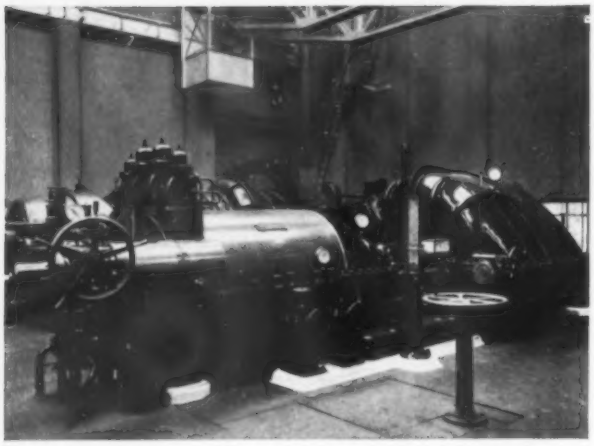
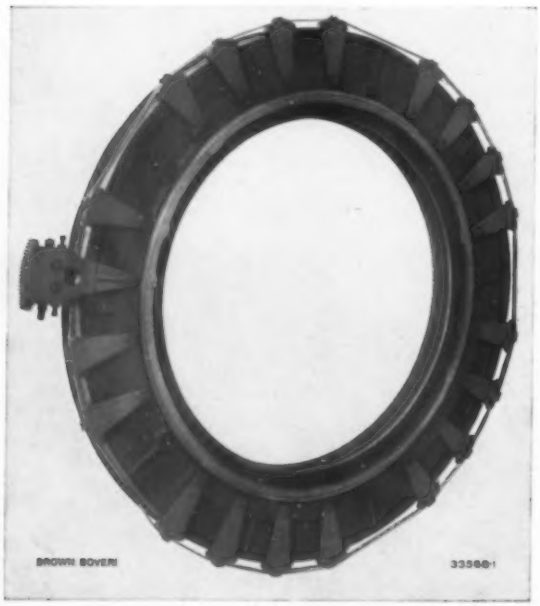


Fig. 2.—Brown-Boveri turbo-blower at Irlam Works.

especially of large output, steam turbine drive is almost exclusively employed. Moreover, as the most efficient regulation of turbo-blowers is obtained by means of speed regulation, steam turbine drive is particularly suitable, as steam turbines can be readily designed to permit of the speed being adjusted from approximately 15% to come to about 35% below the normal speed.

A blast-furnace blower must also satisfy operating conditions, which are subject to severe variations on account of differences in the properties of the ores and coke treated in the furnace, and also the amount and kind of iron being produced. It becomes most important, therefore, to determine beforehand the actual conditions under which the blast-furnace blower will be required to operate, so that when set in service the blower plant will be capable of meeting all the operating conditions which may occur. In some cases it is not always possible to determine the operating conditions accurately beforehand, and in such an event it is advisable to install blower plant fitted with special means of regulation to give a specially large range of stable operation. The fitting of movable diffusers, as described later, is one method of ensuring such a large range of stable operation, and it has even been found possible by the fitting of movable diffusers to increase to a very large extent the range of existing blast-furnace blowers which have been required to operate under conditions which were not foreseen when the blowers were first installed. Such a case is described later.

Fig. 4.—Assembled movable diffuser ring.



Modern blast-furnace practice necessitates on the blower plant some form of regulation gear to ensure either a constant volume of blast being delivered to the furnace, or alternatively the blast being delivered to the furnace at a constant pressure. Generally, when a blast-furnace is provided with its own turbo-blower, regulation to ensure constant volume of blast being delivered to the furnace is provided, but in plants where several blowers serve several furnaces through a common bus main, the regulation is to constant blast pressure. Moreover, when constant volume regulation is utilised it is sometimes specified that a constant weight of dry air be supplied to the furnace, and this can be arranged for very simply by means of a special calculator gauge fitted in conjunction with the constant volume regulation gear. It is also possible to fit the turbo-blower with both constant volume and constant blast pressure regulation gear, and either regulation can be used as required.

The above *resume*, it is hoped, will serve to give some idea of the conditions governing the design and installation of turbo-blower sets for use in conjunction with blast-furnace plant.

Modern Turbo-Blowers.

A representative example of modern blast-furnace turbo-blower practice is the new blower plant installed at the Irlam Works of the Lancashire Steel Corporation, which were fully described and illustrated in our previous issue.

The general arrangement of the new blast-furnace turbo-blower set is shown in Fig. 1, and comprises a Brown Boveri single cylinder turbine, direct coupled to an uncooled Brown Boveri centrifugal blower, the turbine exhausting into a Hick Hargreaves low-level jet condensing plant, located in the basement as shown. In the straight length of suction air piping leading to the blower are located the air-measuring nozzles for the regulation gear of the unit and the air-recording meter. A non-return valve is located in the blower delivery main, and a blow-off valve is provided on the delivery side of the blower for maintaining stable operation of the unit when it is required to deal with very small partial volumes at approximately normal delivery pressure or above. Before the straight length of suction piping leading to the blower there is provided a special silencing chamber to reduce to a minimum the noise which would be set up by the air suction when the blower is dealing with quantities of air up to 60,000 cub. ft. per min., the maximum duty.

The extraction pump of the jet condenser is driven by a Brown Boveri d.c. motor provided with an Allen West starter, with built-in rheostats to permit of speed regulation of the extraction pump-driving motor. The general appearance of the new turbo-blower set is illustrated in Fig. 2.

The turbine is of the single cylinder combined impulse and reaction type, with a single impulse stage followed by reaction stages. The blower is also of the single cylinder type, having three stages, the first and third of which are fitted with hand-operated movable diffusers to enable the blower set to deal with very small volumes of air without pumping.

The impellers of the blower are strongly constructed of high-grade alloy steel, Fig. 3 illustrating the general appearance of a finished impeller.

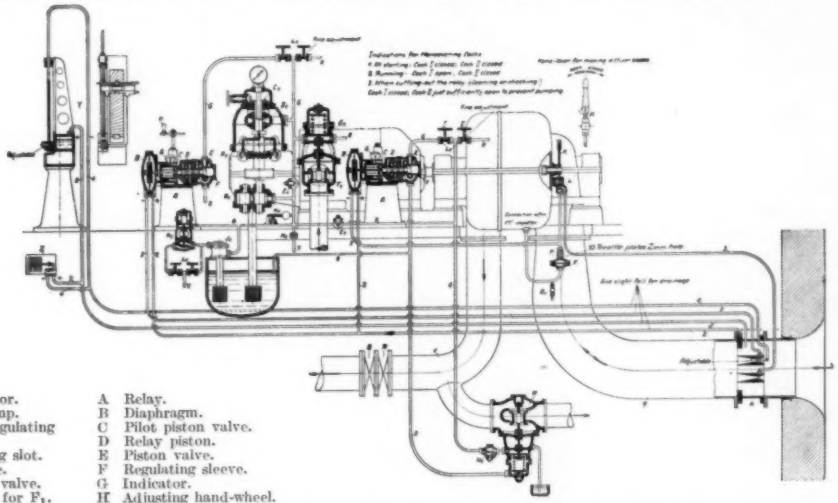
Both the turbine rotor and the blower rotor are fitted with a balance piston on the shaft, and in each machine the rotor is carried in two white metal-lined bearings designed for forced lubrication from the turbine self-contained lubrication system. One of the bearings in each machine is of the combined thrust and journal type, for taking up any unbalanced axial thrust not compensated by the balance piston on the shaft.

The diffuser blades on the second stage of the blower are cast into the blower casing, and the method of fitting the movable blades between the diffuser rings on the first and third stages is illustrated in Fig. 4. Each blade is carried in ball bearings, and the driving crank is keyed on one side to the spindle of the blade. The driving cranks are connected together, as shown in Fig. 4, by a steel wire cable stretched taut, the ends of which are securely fixed to a toothed segment. The teeth of the segment on each movable diffuser engage with corresponding pinions on the operating shaft, which operates all the groups of movable blades simultaneously. The operating shaft is also carried in ball bearings, and is turned by a hand-wheel. The mechanism for adjusting the movable diffusers can be seen in Fig. 2 at the horizontal joint of the blower casing. An indicator with pointer is fixed near the hand-wheel, to show the extent to which the diffuser blades are open.

The diffuser movable blade control gear is interlocked with that of the blow-off valve. When the blower operates at a point outside the stable operating zone for the opening of the diffuser blades, the blow-off valve automatically opens and blows the excess air to atmosphere. This is an indication that the diffuser blades are too wide open for the conditions obtaining, and the attendant can then close the blades by means of the hand-wheel, until the blow-off valve shuts. In this way efficient operation of the blower set without blowing off to atmosphere can be maintained down to exceptionally small duties.

Fig. 3.—Typical blower impeller.

Fig. 6.—Air flow gauge and special calculator for ensuring constant oxygen quantity regulation.



A_1 Main governor.
B_1 Gear oil pump.
C_1 Governor regulating sleeve.
D_1 Oil regulating slot.
E_1 Needle valve.
F_1 Steam inlet valve.
G_1 Servo-motor for F_1.
H_1 Oil safety valve.
J_1 Steam-driven auxiliary oil pump.
K_1 Automatic device for starting-up.
L_1 Cocks.
M_1 Throttle plate.
N_1 Non-return valve with by-pass.

A Relay.
B Diaphragm.
C Pilot piston valve.
D Relay piston.
E Piston valve.
F Regulating sleeve.
G Indicator.
H Adjusting hand-wheel.
K Hand-lever for setting diffuser blades.
L Additional air regulating valve.
M Blow-off valve.
N Amplifying nozzles.
P Multiple throttle-plates.
Q_1 Drain trap.
Q Delivery valve.

R Non-return valve.
V Air filter.
Y Air-flow gauge and calculator.
Z Recording air meter.
1. Air delivery pipe.
2. +Air impulse tubes to A, Y, Z.
3. Air impulse tubes to A. L.
4. — Air impulse tubes to Y. Z.
5. Supply steam pipe.
6. Oil pipes.
7. To the bearings.
8. Oil return pipe.
9. Air intake pipe.

Fig. 5.—Turbo-blower governing diagram for constant volume with blow-off valve.

Both the turbine and blower casings, as can be seen from Fig. 2, are divided horizontally to facilitate dismantling and overhauling. The self-contained lubrication system for the unit comprises a gear oil pump driven from the turbine shaft, and for use when starting up and stopping the set, and also when it is necessary to reduce the speed of the unit to very low values, there is provided an auxiliary steam turbine driven oil pump. The auxiliary oil pump is fitted with special regulation gear, so that it starts up automatically when the main oil pressure falls below a predetermined level, and although the normal operating speed of the turbo-blower set at full duty is approximately 3,000 r.p.m., it is possible safely to reduce the speed of the unit to about 1,100 r.p.m., such as when a "check" is made on the blast-furnace.

The turbine is provided with the standard Brown Boveri system of oil-pressure governing, and all the control gear is of the oil-pressure operated type, ensuring that the accuracy of regulation is maintained throughout the life of the plant.

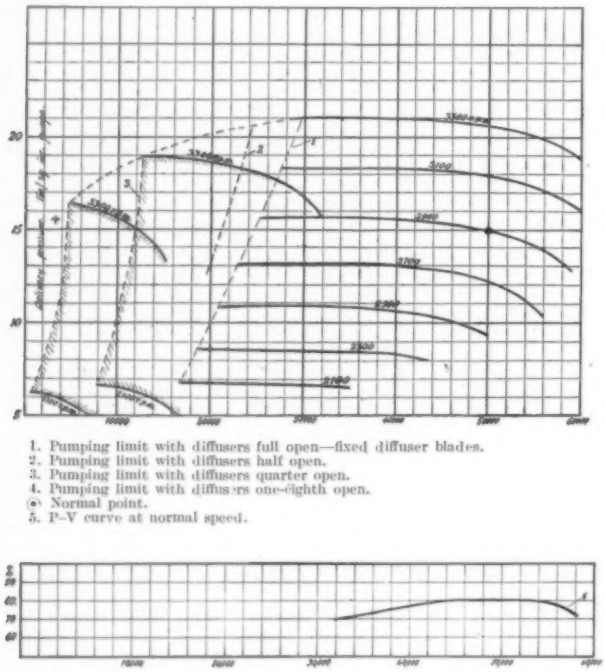
The turbo-blower set is fitted with automatic regulation gear for ensuring a constant volume of air passing through the blower, and, by means of the hand-wheel adjustment provided, the volume of air can be set to any required figure. This regulation gear automatically controls the volume of air passing through the blower at a predetermined figure, irrespective of variations in the live steam pressure and temperature or the vacuum, or even variations in the air delivery pressure set up by the blast-furnace. The complete regulation diagram for the blower set is shown in Fig. 5, which is self-explanatory.

In addition to the automatic constant volume regulation gear, there is also provided a special air flow calculator, illustrated in Fig. 6, by means of which the air volume can be corrected very simply to allow for variations in the temperature and humidity of the air entering the blower, and also variations in the barometric pressure. In other words, by means of the calculator it is possible to ensure a constant dry air—that is, oxygen—quantity passing through the blower set and being delivered to the blast-furnace. As will also be seen from Fig. 5, a recording air-flow meter is provided on the blower set.

The steam turbine is designed for live steam at a pressure of 150 lb. per sq. in. gauge, superheated to 465° F., and for exhausting against a vacuum at the turbine exhaust flange of 28·25" Hg. (Bar, 30").

At the present time the turbine is fitted with steam nozzles specially designed to enable the unit to deal efficiently with a normal duty of 37,500 cub. ft. of air per min. with a delivery pressure of from 12 to 20 lb. per sq. in. gauge, which is the normal quantity of air required by the blast-furnace under the present conditions of operation.

A further set of steam nozzles has been supplied for the turbine, and at a later date, when the blast-furnaces are operating at their full designed output, the turbo-blower set with the further set of nozzles fitted in the turbine will be suitable for a normal duty of 50,000 cub. ft. of air per min. with a delivery pressure of from 15 lb. to 20 lb. per sq. in. gauge. The unit has been tested with this further



1. Pumping limit with diffusers full open—fixed diffuser blades.
2. Pumping limit with diffusers half open.
3. Pumping limit with diffusers quarter open.
4. Pumping limit with diffusers one-eighth open.
- Normal point.
5. P–V curve at normal speed.

6. Polytropic efficiency corresponding to P–V curve 5.

Fig. 7.—Characteristic curves of turbo-blower set at Irlam.

set of nozzles fitted in the turbine, and is actually capable of dealing with up to 60,000 cub. ft. of air per min. with a delivery pressure of from 12 lb. to almost 19 lb. per sq. in. gauge, and even about 55,000 cub. ft. of air per min. with a delivery pressure of 20 lb. per sq. in. gauge.

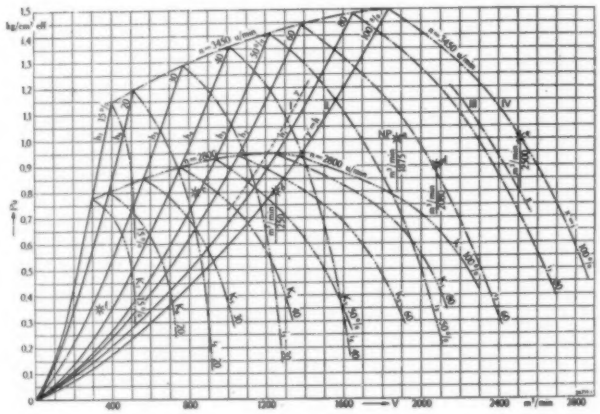
At the present normal duty of the turbo-blower set—viz. 37 500 c.f.m. 15 lb. per sq. in. gauge, the speed is approximately 2,800 r.p.m., and at the normal designed duty of 50,000 c.f.m., 15 lb. per sq. in. gauge, the speed is approximately 2,900 r.p.m.

The characteristics of the turbo-blower set are illustrated in Fig. 7, the dotted lines 1, 2, 3, and 4 being the pumping limits, with various degrees of opening of the movable diffusers. Line 1 is the normal pumping limit with the movable diffusers full open—that is, equivalent to fixed diffuser blades; line 2 with the movable diffusers half open; line 3 with the movable diffusers one-quarter open; and line 4 with the movable diffusers only one-eighth open. It will be noted that by means of the movable diffusers the stable range of operation of the turbo-blower set extends from below 5,000 c.f.m. to 60,000 c.f.m. at the normal delivery pressure of 15 lb. per sq. in. gauge, and this extensive stable zone is obtained efficiently without blowing off to atmosphere.

The movable diffusers also permit of the turbo-blower set being started up in a very simple manner, as it is necessary only to run up the set to speed against closed diffusers, and then gradually to open the diffusers, when the turbine will immediately take up the load and the blower will commence delivering air into the system. Since the turbo-blower set was put in service at the end of last year, the operation has been entirely satisfactory, and no trouble of any kind has been experienced with the control gear, automatic constant suction volume regulation gear or the operation of the movable diffusers on the blower.

Advantages of Movable Diffuser Regulation.

The above example demonstrates the extreme flexibility of a blast-furnace turbo-blower set, and the extended zone of stable operation which it is possible to obtain, with movable diffuser regulation, but a great advantage of this



Abscissae: Intake volume. Ordinates: Blast pressure in kg/cm² gauge.
a. Specified normal point.
b. Actual normal point in service.
c. Actual working point for the blowing when reducing special kinds of iron.
d. Actual working point when one blower serves two blast-furnaces.
e. Largest intake volume in service at the specified final pressure.
f. Working condition when tapping the blast-furnace.
x. Calculated highest pressure-volume curve.
*x*1. Actually obtained highest pressure volume curve.
y. Calculated pumping-limit.
y_7. Pumping limit actually obtained in service.
h to *h*1. Pumping-limits at 100, 80, 60, 50, 40, 30, 20 and 15% diffuser opening.
i to i_7. Pressure-volume curves at 3,450 r.p.m. and 100, 80, 60, 50, 40, 30, 20, and 15% diffuser opening.
k to k_7. Pressure-volume curves at 2,800 r.p.m., and 100, 80, 60, 50, 40, 30, 20, and 5% diffuser opening.

Fig. 8.—Characteristic curves for blast-furnace turbo-blower set fitted with Brown-Boveri diffuser regulation.

system of regulation for blast-furnace blowers is well illustrated from an example which occurred in practice and is clearly explained with the aid of the characteristic curves shown in Fig. 8.

In 1929 Brown Boveri received an order for two steam turbo-blowers intended for a new blast-furnace plant, each blower to serve its own blast-furnace, the daily output of which was estimated at 600 metric tons. With a blast pressure of 1 kg. per sq. cm. gauge (14·2 lb. per sq. in. gauge) each blower set was specified to be capable of dealing with 1,875 cubic metres of air per min. (about 66,000 cub. ft. per min.), with a maximum of 2,350 cubic metres per min. (about 83,000 cub. ft. per min). Further, at a maximum pressure of 1·5 kg. per sq. cm. gauge (about 21·3 lb. per sq. in. gauge) the blowers were each to be capable of dealing with 1,300 cubic metres of air per min. (about 46,000 c.f.m.).

At the time of erecting the blowers, the fitting of movable diffuser blades was considered unnecessary, as it was maintained that it would not be necessary to run the units at partial loads. When the blast-furnaces were set in service, however, it was found that the actual service conditions differed considerably from those specified when placing the order. Subsequently, the factors bearing on the design of the blowers were investigated, and the following result was disclosed.

The coke consumption had been assumed at 1·1 tons per ton of iron (metric tons), but actually amounted to only 0·95 tons. The amount of air considered necessary to burn 1 ton of coke had been determined on the basis of many years experience with gas engine-driven reciprocating blowers to be 3,500 cubic metres per min. On top of this, a 10% addition had been made to counterbalance leakage losses in the pipes and fittings. The specified pressure at the blower delivery branch had also been estimated too high, as tests showed that a blast pressure of 0·8 kg. per sq. cm. gauge (about 11·4 lb. per sq. in. gauge) was sufficient to pass the necessary air through the furnace. The pressure-volume curves in Fig. 8 show clearly the difference between the estimated normal point *a* and the actual working point *b*.

In considering the performance of the blowers, it is particularly interesting to note the position of the pumping limit for the machine with fixed diffuser blades, as supplied. When operating under any conditions represented by points lying to the left of the pumping limit, compressed air must be blown to atmosphere through the blow-off valve, thus incurring a corresponding loss of power. Moreover, the designer, with a desire to make certain that the blower would be capable of meeting all eventualities, designed the machine on the large side so that for a daily production of 600 metric tons of iron the actual working point *b* lay practically on the pumping limit. As a result of this, a decrease in the quantity of air or an increase in the blast pressure necessitated blowing off to atmosphere with a corresponding loss.

Contrary to the original intention, only one of the two furnaces could be run for the full production of 600 tons per 24 hours. The daily output of the second furnace had to be reduced to 400 tons, and as a result the intake to the blower serving this furnace fell to 830 cubic meters per min., point *c* in Fig. 8. This point also lay in the unstable field of operation for the blower fitted with fixed diffusers, with resultant blow-off losses.

The blowing plant of a new blast furnace works fitted with all the latest developments for producing the best quality material could, naturally, not be allowed to remain operating in such an inefficient manner, and movable diffuser blades were fitted to each blower set as being the simplest and least expensive means of improving the operation. The results actually obtained after fitting movable diffuser blades are clearly shown by the curves in Fig. 8. To the left of the pumping limit line for the blower when fitted with fixed diffuser blades another zone can be included in the field of stable working, in that by adjusting the opening of the diffuser blades, blowing off of compressed air to atmosphere to prevent pumping can be avoided entirely. To each opening of the diffuser blades corresponds a different pumping limit, which has been plotted, and is shown in Fig. 8, for various openings of the movable diffusers. By thus eliminating the blow-off losses, a corresponding reduction in the power input results, and the particularly important conditions of operation—viz., the points *b* and *c*—can be economically obtained by each blower serving its own furnace alone, and without experiencing any blow-off losses.

Until the movable diffuser regulation gear was fitted, the difficulty was alleviated by running one turbo-blower to serve both furnaces, producing together 1,000 tons per day, this condition corresponding to point *d* on the curves in Fig. 8.

As it happened, the turbo-blowers were largely dimensioned, and the blast requirements of both furnaces for an iron production of twice 600 tons per 24 hours could be dealt with by a single turbo-blower, this condition being point *e* in Fig. 8. This large volume of air of 2,500 cubic metres per min. (about 88,000 cub. ft. per min.), at a maximum speed, was approximately 33% above the normal output originally specified.

When tapping a furnace, the blast quantity and pressure is often considerably reduced, and this condition is shown at *f* in Fig. 8. By using movable diffuser blades, this point lies well within the range of stable operation, and the extreme opposition of the two points *e*, overload, and *f*, at tapping, shows the extraordinarily large range of stable operation of the turbo-blowers fitted with movable diffuser regulation.

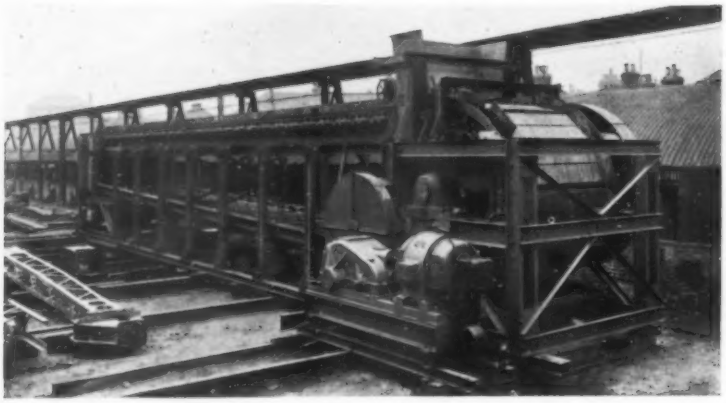
In conclusion, it may be mentioned that in addition to the Brown Boveri steam turbine, which has been manufactured in this country for many years, arrangements have been completed for the manufacture in this country of all types of Brown Boveri turbo-blowers and turbo-compressors.

Wear-Testing Machine for Cast Iron

To test the wear resistance of cast iron under conditions similar to that met with in practical service, a special apparatus has been designed by F. Heimes and E. Piwowarsky. To reproduce conditions where rolling friction prevails a mill is provided for consisting of two bottom rolls which are coupled with the motor, and a top roll running between them. By means of weights acting on the bearings of the top roll varying loads can be applied to the test-piece running between the three rolls. The bottom rolls can be driven with different speeds so that the test samples slip. The rolling speed of the latter is about 15 miles per hour. To determine the abrasion under sliding friction the test-piece is pressed by means of a holder against a horizontally rotating disc, consisting either of hardened steel or of the material to be tested. The test-piece is moved radially on the disc so that the entire surface of the latter is evenly worn away. Through the holder a thermometer can be inserted into the test sample, and a spring balance attached to the holder measures the lateral pressure exerted by the disc on the sample. To determine the abrasion which iron parts undergo when working in sand or soil, a pot is provided for which is filled with abrasive material, and in which the test sample attached to a vertically rotating cranked shaft, describes a circular way. Further, there is a vertically rotating disc made of mild steel (a so-called Spindel saw) against the edge of which the sample is pressed with varying pressure. Disc and test-piece are cooled with compressed air.

Experiments carried out with cast irons of varying compositions showed that, generally, the abrasion under rolling friction decreases with increasing hardness of the iron. Low hardness, however, can also be associated with a high wear resistance, particularly when the iron is alloyed with nickel. Perlite is more resistant than ferrite. With increasing fineness of the graphite flakes the abrasion increases. This is due to the fact that with finer graphite particles the rolled-in air can penetrate at many places below the surface and oxidise the iron. Under sliding friction the pearlitic irons showed a markedly higher wear resistance than the ferritic ones. Phosphide and cementite increase the wear resistance when the iron is tested on the hardened steel disc but decrease it when tested on a disc of the same composition because the torn-off hard particles act like emery. Graphite acts as lubricant, and it seems that there is a best graphite content above and below which abrasion increases; at lower contents due to insufficient lubrication, at higher contents due to the coarseness of the structure. The fineness of the graphite affects the wear resistance in the same way as under rolling friction: the finer the graphite the higher the abrasion. Tests with the Spindel saw and the abrasion pot gave similar results. (Archiv für das Eisenhüttenwesen, May, 1933.)

Sintering of Iron Ores



The application of sintering processes for agglomerating fine ores, as well as dust, is increasing, especially as by this method results are being obtained with ores which formerly were difficult to utilise. The Dwight-Lloyd machine, an installation shown in the accompanying illustration, with a capacity of 600-700 tons per 24 hours, is designed to make the process continuous.

DURING recent years great advances have been made in the utilisation of fine iron ores; this has been made possible by sintering or agglomerating the fine ores in special machines. The same applies to the treatment of many other ores, particularly those of lead, zinc, copper, nickel, and manganese, desulphurising also being carried out at the same time. The progress in this field is indicated by a "Dwight-Lloyd" sintering machine to deliver 800–1,000 tons of sintered iron ore per 24 hours, which is now in course of construction at the new Corby Ironworks (Lincolnshire) to the order of Stewarts and Lloyds, Ltd. This is being supplied by the firm of Huntington Heberlein and Co., Ltd., London, which has recently completed a similar installation but with a capacity of 600–700 tons of sintered ore per 24 hours, for the Ford Motor Co., Ltd., of Dagenham.

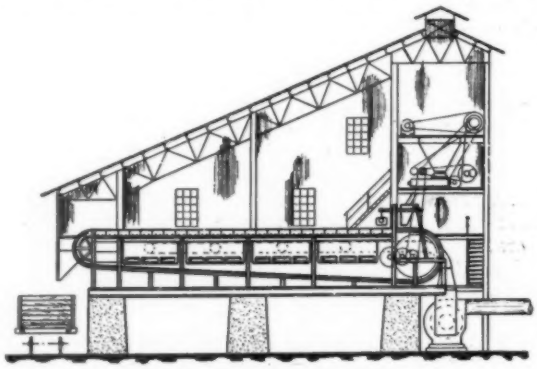
The basic principles upon which this type of machine is designed are noteworthy. For blast-furnace practice these consist in mixing the finely divided iron ore and similar material, such as pyrites, cinders, and blast-furnace dust, with a carefully regulated amount of finely divided solid fuel, generally coke breeze or anthracite, and then burning the latter as the mixture is caused to travel on a long, horizontal, slow-moving, endless travelling chain of the "straight-line" type, composed of a series of small carriage or "paletts" having a flat bottom constructed of grate bars.

The mixture of fine ore and fuel, to which also a small amount of water has been added, is fed on to the endless travelling chain of carriages at one end of the setting, forming a uniform layer about 7–12½ in. thick. Almost immediately the latter passes under a combustion chamber, fired with any convenient gaseous, liquid, or solid fuel, such as blast-furnace gas or coke-oven gas, for example, so that the coke breeze in the mixture is ignited. The contents of the carriages are then subjected to powerful suction from underneath by means of a system of trunking with a fan, so that air is pulled downwards through the product as it travels, burning the whole of the coke breeze.

As a result, because of the heat, the finely divided iron ore particles are slightly melted and agglomerated or sintered, giving large porous grains of iron ore, the bulk of which are of a size between a range of 0·15 in. and 1·20 in., forming a highly satisfactory product for treatment in the blast-furnace and much superior to the raw iron ore, especially when in the finely divided form.

This operation of sintering has, however, to be carried out on very accurately controlled lines, not only as regards the percentage of coke breeze in the mixture and the thickness of the layer, but also the intensity of the draught, that is, the volume of air passing through. If the conditions are not correct, then either the temperature may be too high, resulting in actual clinkering of the iron ore, or it may be too low, when the sintering is irregular and incomplete.

At the end of the travel the carriages travel round a large supporting end roller and open apart, the material falling over a "grizzly" or screen, generally with ¾ in. bars, so as to separate the fine dust below 0·15 in. size, mostly unsintered material, which is returned for further treatment. The graded sintered iron ore can, if necessary, also be further screened, so as to separate the larger pieces, which may be used to form the floor or "dressing" of the grate bars on the travelling carriages, to give a protecting effect from the heat. In many cases, however, this further



Showing operation arrangement.

grading is not necessary, and limestone chips are used instead as a dressing, the whole of the sintered, porous iron ore particles being passed direct to the blast furnace. When sulphur is present a considerable amount of valuable desulphurising takes place, as already indicated, and the plant, of course, has to be designed and operated to suit the particular conditions of the ore and the results desired.

The standard very large high-duty modern straight-line "Dwight-Lloyd" machine is 85 ft. long and up to 6 ft. 6 in. wide, with an actual surface of 450 sq. ft., through which air is passing with a duty of 1,000 tons of sintered ore per 24 hours. Machines are supplied also in standard sizes of 100–1,000 tons of sintered ore per 24 hours capacity, under normal conditions, each particle of the charge being treated for 10–20 mins.

METALLURGIA

The British Journal of Metals

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METALLURGIA

THE BRITISH JOURNAL OF METALS.

Industrial Recovery by Control

CONSIDERABLE discussion has taken place recently regarding the possibility of raising prices of essential commodities by international agreement to limit the production of certain goods. But it has been left to President Roosevelt to put a scheme into operation that includes, among other far-reaching proposals, the compulsory limitation of output in a great number of industries. In view of the lamentable condition of industry in many countries, world traders and industrialists are watching with deep concern the operation and ultimate outcome of the social legislation included in the Industrial Recovery Act as the plans are prepared and adopted. Apparently a code of procedure has been, or is being, prepared under the direction of President Roosevelt to suit the peculiar conditions of each industry concerned.

Not even in the United States is it expected that this legislation will overcome all the current problems of the economic and social system of that great country, nor that it will proceed successfully without grave difficulty. But there can be no question that the unanimity of opinion throughout the country on the need for such legislative action will have a very great influence on the development of this movement. There will naturally be differences of opinion regarding the methods employed, but it will be noted that the responsibility for the preparation of suitable codes is being thrown upon those directly concerned with the industry each code will control; thus it is the leaders rather than the Government who are being made responsible for the reconstruction of social conditions involving hours of labour, employment and production, with the object of restoring what is recognised as normal and profitable conditions to trade and industry.

This legislation provides the power to enforce ethical trade practices which are endorsed and followed by the majority in each section of trade. It permits employers to do, by agreement, what none of them would care to risk doing separately. But we are convinced that the further President Roosevelt proceeds with his reconstruction programme, the more he will be forced to interfere with industry. Already a new Board of Mediation has been set up under pressure from trades unions, as a safeguard against strikes or lock outs, and apparently employers will be expected to submit to Government interference of a character no previous President has considered possible in a country so characteristically individualistic, despite the efforts to throw the responsibility upon trades and industries.

Industry can and should adjust itself to meet new conditions, and the less the interference of Governments the more stable will be the recovery, but it seems paradoxical that efforts should be directed towards recovery by limiting production when actually an increase in the supply of goods is necessary. It is not over-production we are suffering from, but under-consumption, and attention should be directed to the problem of increasing the demand for goods and not in restricting supplies. It is probable in some exceptional instances that the production of particular commodities has exceeded not merely the world's present curtailed consuming power, but the probable demand even under prosperous conditions. In such cases curtailed production could be arranged, but only in exceptional instances is it possible to contend that there is overproduction in relation to the potential demand.

A very real effort is being made to raise prices in the United States. This is necessary everywhere, because at present prices are out of adjustment with the structure of incomes and debts throughout the world, and at their present levels they do not provide a sufficient incentive to the employer to produce or enable a reasonable living wage to be paid, but it is not desirable to make prices higher at the expense of the world's standard of life. To force up prices by limiting supply is surely not a progressive step, since it panders to the forces of selfishness which tend to circumvent the underlying needs of mankind and to interfere with social reconstruction. And to assert, as some do, that by limiting production and raising prices a greater demand will be fostered that will cause an increase in production is surely another paradox that would need much explanation to achieve any degree of satisfaction. Restriction in order to raise prices, except in a few special cases, is unworkable, as well as unsound as a general policy.

Despite criticism to which President Roosevelt has laid himself open, he is to be praised for his courage and foresight in launching a scheme which is finding such general acceptance in the United States, although its success appears to be patchy. According to the latest reports, there is little doubt that in the large industrial centres the scheme has already led to the employment of hundreds of thousands, but difficulties are being experienced in the small towns. It seems that minor industries and scattered units are difficult to control. On the whole, however, the general success so far achieved is a happy augury, and the people recognise that any recovery scheme that has successful possibilities is better than industrial and trade stagnation.

Fears have been expressed regarding the possibility the scheme affords for official corruption, and it has been suggested that should Mr. Roosevelt's plans break down it will be due to this cause. But those who have watched the formation of the administration for the Industrial Recovery Act will have noted that the three chief men chosen are of the most rigid standards. Their selection has enhanced public opinion and given an indication that disinterested service will predominate. All progressive minded people in the United States seem to appreciate that in appointing Mr. Harold Ickes, the Secretary of the Interior, Mr. Henry Wallace, the Secretary of Agriculture, and General Hugh Johnson, the Administrator of N.I.R.A., to carry out this economic experiment, corruption is unlikely to escape their vigilant eyes.

It is noteworthy that the industrial recovery programme has already been responsible for the termination of some of the most shocking conditions of sweated labour and of child labour. For years efforts have been made to put an end to child labour without success, General Johnson, however, by simply introducing a minimum wage clause, which made it unprofitable to employ children, succeeded in getting rid of the evil in very quick time.

With the continued support of the American people, this experiment may well serve to show what can be achieved by a forceful and energetic government, and may provide a way out of the present depression from which other countries would profitably derive administrative information that could be applied with at least equal success. In any case, no country can succeed without influencing other countries, and it may be that Mr. Roosevelt's experiment may revitalise the industrial world and lead to universal recovery.

British Trade Figures Show Hopeful Signs

ALTHOUGH the actual increases in the total imports and exports during July, in comparison with those during the corresponding month of last year, are not impressively large, they are sufficient to confirm the impression that has been felt for some time that trade conditions are on the mend. The actual totals of trade as given by the Board of Trade are as follows :—

	July, 1932.	July, 1933.	Increase.
	£	£	£
Imports	51,912,265	53,706,227	1,793,962
Exports	29,293,688	29,847,341	553,653
Re-exports	3,304,757	4,323,719	1,018,962

The recovery in the re-export trade is particularly welcome, following a similar expansion in June. It is in the figures for the manufacturing export trades, however, which encouragement especially lies. More than half the twenty classified trades show an increase, although, unfortunately, the position in total exports is obscured by the fall in Lancashire's cotton export trade. A substantial increase of £972,417 in the exports of non-ferrous metals and manufactures, while vehicles show an increase of £291,897. Some of this improvement is undoubtedly due to the activity which has resulted from the United States recovery programme. Under non-ferrous metals, for instance, tin shows an export of 4,200 tons last month, mainly to the United States, as compared with 1,081 tons in July, 1932. Improvement under vehicles indicates better business in rail and road transport material. Shipbuilding figures continue to reflect depression, although July shows some improvement.

It is too early to state that the depression is really lifting, but there is an optimistic feeling abroad which is supported with expressions of confidence by leading manufacturers. A good sign is the increased amount of steel being purchased by engineering firms, as well as improved orders from the Continent. In Sheffield, where the output of ingots and castings is greatly in excess of a year ago, many firms are working at full pressure to ensure deliveries. The main industries in South Staffordshire continue to show steady improvement ; this not only applies to the lighter branches of industry, but the heavy sections also. With the enormous development on Tees-side, the outlook in this area is decidedly brighter, while plants in Lincolnshire are being maintained relatively busy. So brisk is the open-hearth steel section that several big rolling mill plants are working on Sundays. At the Parkgate Iron and Steel Works a ninth furnace is being prepared. Full time is being worked at Lysaghts, Scunthorpe, and the Redbourne Hill Works at Scunthorpe, recently restarted, have four open-hearth and two blast furnaces in operation. Arrangements at these latter works are completed for the transfer of the Whitehead Co.'s continuous rolling mill, now working in South Wales.

In almost every direction confidence in the future is spreading, and it is thought that trade will continue expanding over the remaining months of the year. The position just now is certainly one which cannot fail to give encouragement without being unduly optimistic.

Jubilee Meeting of Institute of Metals

THE arrangements for the forthcoming Silver Jubilee meeting of the Institute of Metals are completed. Special facilities will be afforded to original members of the Institute attending the reception to meet in a reconstruction of the office where Mr. Shaw Scott began his secretarial duties on the formation of the Institute. This office was in the Museum of the Metallurgical Department of Birmingham University. Guests at this reception will have an opportunity of seeing original records of the early efforts of the pioneers.

The members will assemble in Birmingham on Monday, September 18, and on the same evening the twelfth autumn lecture will be delivered at the University, Edmund Street, by Mr. W. R. Barclay (vice-president), on "Twenty-five Years Progress in Metallurgical Plant."

The headquarters of the conference will be the Central Technical College, Suffolk Street, where on the Tuesday morning the members will be welcomed by the Lord Mayor of Birmingham (Councillor H. E. Goodby). Papers on technical subjects will be read and discussed, and the members and their ladies will be the guests at luncheon of a number of metallurgical associations. In the afternoon visits will be paid to several metallurgical works, and in the evening there will be a reception by the University of Birmingham at Edgbaston, when the guests will be received by the Pro-Chancellor (Mr. Walter Barrow).

The general meeting of members for the discussion of technical papers will be resumed on the Wednesday morning, and the afternoon has been allotted to more visits to works. In the evening there will be a civic reception by the Lord Mayor and Lady Mayoress at the Council House. The concluding day, Thursday, will be devoted to a motor-coach excursion through the Cotswold country, the party calling at Stratford-on-Avon to inspect the Memorial Theatre.

Arrangements have also been made for members to visit any one of the following works :—Earle, Bourne and Co. Ltd., Austin Motor Co. Ltd., General Electric Co. Ltd., I.C.I. Metals Ltd., London Aluminium Co. Ltd., while special arrangements are made for ladies.

The technical papers to be presented will include : — "Constitution of the Silver-Rich Aluminium-Silver Alloys," by N. W. Ageew and D. N. Shoyket ; "Experiments in Wire Drawing. Part III.—Annealing of High-Conductivity Copper Wires Drawn to Varying Degrees of Hardness," by W. E. Alkins and W. Cartwright ; "Further Observations on the Distribution of Porosity in Aluminium and Copper Ingots, with Some Notes on Inverse Segregation," by N. P. Allen ; "Magnesium Alloy Protection by Selenium and Other Coating Pricesses," by Dr. G. D. Bengough and L. Whitby ; "The Properties of Some Temper-Hardening Copper Alloys Containing Additions of Nickel and Aluminium," by Dr. H. W. Brownsdon and Dr. Maurice Cook ; "Corrosion Fatigue Characteristics of an Aluminium Specimen Consisting of Two Crystals," by Dr. H. J. Gough and D. G. Sopwith ; "Wear in the Polishing of Plated and Other Surfaces," by Dr. O. F. Hudson ; "A Graphical Method for Converting the Weight Percentage Compositions of Ternary Systems into Atomic or Molecular Percentages," by Dr. W. Hume-Rothery ; "Notes on the Preparation of Lead and Lead Alloys for Microscopic Examination," by Brinley Jones ; "Precipitation-Hardening Nickel-Copper Alloys Containing Aluminium," by D. G. Jones, Dr. L. B. Pfeil, and W. T. Griffiths ; "An Investigation of the Heat-Treatment of Standard Silver," by Dr. Hugh O'Neill, G. S. Farnham, and J. F. B. Jackson ; "Some Steps in Metallurgical Progress, 1908-1933," by Dr. W. Rosenhain ; "The Constitution of Aluminium-Rich Aluminium-Copper Alloys above 400° C.," by Dr. D. Stockdale ; "Notes on the Green Patina on Copper : Examples from Elan Valley (Wales) and Dundalk (Ireland)," by Dr. W. H. Vernon.

Autumn Meeting of Iron and Steel Institute.

A COMPREHENSIVE range of technical papers will be submitted for discussion at the autumn meeting of the Iron and Steel Institute, to be held in Sheffield on September 12 to 15. The technical sessions will take place in the Mappin Hall of the University of Sheffield on September 13 and 14, commencing at 10 a.m. each day. The papers to be presented include: "Heat Conservation at the Normanby Park Steel Works, Scunthorpe," by W. J. Brooke; "Notes on the Utilisation of Blast-furnace Gas," by W. B. Baxter; "Some Factors Leading to Greater Production from a Steel Furnace," by A. Robinson; "The Effect of Tin as an Impurity in Mild Steel," by J. H. Andrew and J. B. Peile; "Fifth Report on the Heterogeneity of Steel Ingots"; "The Influence of Beryllium on Steel" by J. H. S. Dickenson and W. H. Hatfield; "Alloys of Iron Research. Part XI.—The Constitution of the Alloys of Iron and Manganese," by M. L. V. Gayler; "A Coke-fired Reheating Furnace," by F. Lloyd and R. V. Wheeler; "Some Experiments on the Resistance to Wear of Nitrogen-hardened Cast Iron," by J. E. Hurst; "The Thermal Conductivity of Wrought Iron, Steel, Malleable Cast Iron, and Cast Iron," by J. W. Donaldson; "The Effect on Various Steels of Hydrogen at High Pressures and Temperatures," by N. P. Inglis and W. Andrews; "Improving the Coking Performance of Weakly-caking Coals," by R. A. Mott and R. V. Wheeler; "Some Properties of Cold Worked Sorbitic and Austenitic Alloy Steel Wire," by S. H. Rees; "The Effects of Pickling on the Properties of Carbon Steels," by I. G. Slater; "A Note on the Effect of a Backward Pull upon the Tension Required to Draw Wire," by F. C. Thompson.

It is not expected that all these papers will be presented for discussion, but, subject to the direction of the President, the first four papers mentioned will be considered on September 13, and the next five on September 14.

Electrochemists' International Corrosion Meeting.

THE International Convocation on Corrosion, sponsored by the Electrochemical Society, will be held at the Hotel Stevens, Chicago, on Thursday morning, September 7, 1933. No subject is attracting greater world-wide attention among engineers, chemists, and industrial leaders than that of corrosion. The most important metal to be protected is steel. A. W. Hothersall, of London, will discuss the "Adhesion of Electrodeposited Coatings to Steel." Karl Daeves, of Dusseldorf, Germany, will emphasise the "Effect of Composition and Pre-treatment of Steels upon the Life of Protective Coatings." E. Herzog, of Lille, France, will present his views on the "Value of Electrodeposits in Protecting Iron." S. C. Britton and Ulick R. Evans, of Cambridge, England, will report on their scientific study of "Protective Painting," and Manfred Ragg, of Hamburg, Germany, will advocate the "Use of Lead Pigments to Protect Iron and Steel." Oliver P. Watts, of the University of Wisconsin, will present the most modern interpretation of the "Theory of Corrosion." K. H. Logan, of the Bureau of Standards, Washington, will submit detailed data on "Tests Made on Iron Pipes Embedded in Damp Soil." Among others to participate in this international convocation on corrosion are Lobry de Bruyn, of Amsterdam, Holland; L. Hajda, of Dratnova, Czechoslovakia; and F. N. Speller, of Pittsburgh, who will act as chairman of the meeting.

Faraday Centennial Celebration.

It is just one hundred years since Faraday made the epoch-making discovery of the two laws that form the very foundation of the whole electrochemical science and industry. This event will be appropriately celebrated at the Chicago Fair (Illinois Host Building), Friday afternoon and evening, September 8, "Faraday Day." Prof. R. S. Hutton, Goldsmiths' Professor of Metallurgy at the University of Cambridge, England, is the guest of honour of the Society, who will deliver the Faraday address.

Permeability of Steel for Hydrogen.

G. LEWKONJA and W. Baukloh have studied the permeability for hydrogen of Armco iron and several steels containing up to 1 per cent. of carbon, in the temperature range of from 700 to 1,000° C. The pressure difference was one atmosphere. In the beginning of the test part of the hydrogen is consumed for saturating the iron. The permeability of Armco iron increases slowly between 720 and 860° C., then more rapidly, the increase being proportional to the rise in temperature. With decreasing wall-thickness the permeability increases rapidly. the curves showing a hyperbolic form. At the β—γ transformation point the permeability is nil. From this the authors conclude that the hydrogen exclusively travels along the grain boundaries and not through the crystal lattice. With steels the permeability starts about 1 to 2 hours after beginning the test, rapidly increases to a maximum value, and then slowly decreases. The decrease can be ascribed to the progressive formation of ferrite. Generally, the permeability of steels is higher than that of Armco iron, and increases with increasing carbon content. With rising temperature it seems to approach a maximum value. This fact is probably caused by that the depth of the ferritic layer ceases to increase even at high temperatures because the carbon diffuses from the centre into the outer layers. With some steels the permeability at the β—γ transformation point was nil. With increasing grain size the permeability increased. Steel containing 0·115 per cent. of carbon which was heated in ferro-aluminium powder at 1,000° C., and showed a calorised case 0·5 to 0·6 mm. thick, proved entirely hydrogen-tight at 850° C. (Archiv für das Eisenhüttenwesen, April, 1933.)

Primary Structure of Steel.

As G. Tammann and G. Bandel have shown in the January issue of Archiv für das Eisenhüttenwesen, the primary crystal structure of steel can be revealed by adding the radio-active thorium B to the melt. The crystals separating first from the molten metal are almost free from thorium, which accumulates at the end of solidification along the grain boundaries or in non-metallic inclusions. When a polished test sample is placed on a photographic plate the latter is darkened at those places where it is hit by the α-particles emanating from the thorium. Therefore in the radiogram the crystals which solidified first will show a bright appearance, while the boundaries are dark. The distribution of light and darkness in the radiogram is, therefore, inverse to that found in a microphoto of a sample etched with Oberhoffer's reagent, which also reveals the primary crystal structure. The thorium content of the steel samples investigated was $1 \cdot 10^{-6}$ % at best. The time of exposure of the photographic plates was 24 hours. Electrolytic iron gave an evenly darkened radiogram. Small additions, such as FeO,Mn and Si, produced an uneven distribution of the shadows. Electrolytic iron with 0·2% of sulphur showed a granular structure, iron with 0·2% of phosphorus a dendritic structure. Further radiograms show the primary structure of several carbon steels, microphotos of the same steels etched with Oberhoffer's reagent are added for comparison. Non-metallic inclusions appear in the radiogram on an enlarged scale, therefore submicroscopic particles can also be made visible. The primary structure of cast metals can also be revealed by adding the radioactive metal uranium to the melt. Because of the exceedingly long radioactive period of this metal, higher contents and a longer time of exposure are required. Two radiograms of nickel containing 6% and 21% of uranium, respectively, are shown.

Beilby Memorial Awards.

The administrators of the Beilby Memorial Fund (the Presidents, Honorary Treasurers, and Secretaries of the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals) have announced the award of one hundred guineas each to Dr. Constance E. Tipper (*née* Elam), of the Engineering Department, Cambridge University, and to Dr. Arthur Joseph Victor Underwood, Chemical Engineer.

The Electrodeposition of Nickel and Chromium*

By J. W. Cuthbertson, M.Sc.

Chromium Plating.

The introduction of chromium plating has brought about great changes in the technique of commercial electroplating. Two processes are employed: one which produces a dull finish and the other a bright finish. The solutions and operations of the bath in these processes are discussed in this article.

IN the case of nickel plating, there is not much difference between the anode and cathode efficiencies; approximately as much metal is deposited at the cathode as is dissolved from the anode for a given quantity of electricity. With chromium plating solutions, however, the cathode efficiency is much lower than that of the anode; it is rarely greater than 15%. This means that if chromium anodes are used the solution will rapidly become too rich in chromium. It is therefore advisable to use an insoluble anode and to make up for the metallic chromium deposited by the addition of chromium salt.

There are two processes by which articles may be electrolytically plated with chromium: (1) from a dull solution; (2) from a bright solution. The former is worked at a higher current density than the bright solution; the deposit is dull greyish in colour and must be finished. As electrodeposited chromium is usually very hard, the finishing presents great difficulties, and probably accounts, to a considerable extent, for replacement of this type of bath by that giving bright plate. One purpose for which the dull solution is still used is for depositing chromium upon worn parts, for protecting dies and gauges, etc., where the finishing required is either simple or need not be so perfect as when appearance is of paramount importance.

Most chromium plating to-day is carried out from a bright solution. In this case the article should always be nickel plated first and carefully prepared. It is then immersed in the chromium vat for about 15 mins., and when withdrawn requires little or no finishing, the deposit being quite bright. The production of a bright deposit is only possible if the solution is worked between certain comparatively narrow limits as regards temperature, current density, and composition. Fairly accurate control of these factors is essential. The temperature is adjusted by regulation of the gas supply to the heaters; it is not usually difficult to keep this constant. Current density must be determined from a rough calculation as to the size of the cathodes. Bath composition control is not so easy; before discussing this it will be better to describe the type of solution that is used to produce bright plate.

Solutions.

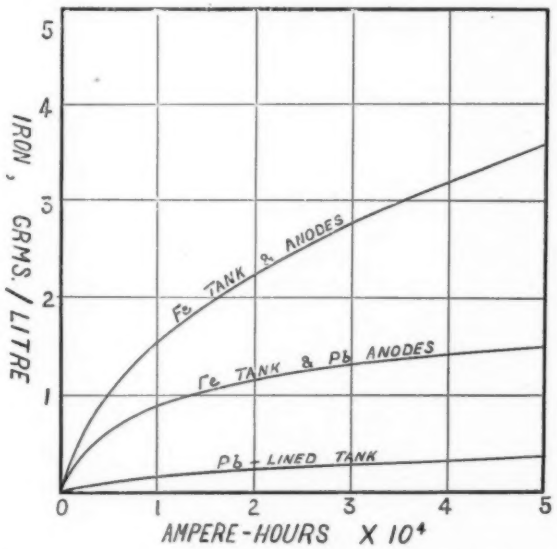
The essential constituent of all chromium plating solutions is chromic acid. This must be pure, particularly as regards freedom from sulphates. The solution is very dense, containing from 300 to 500 grms. of chromic acid per litre. The only other material necessary is a sulphate; sulphuric acid is commonly used, and can easily be obtained pure. There is a definite relationship between the proportions of sulphate and chromic acid, which must always be maintained if the bath is to work satisfactorily. The matter is too complex to be considered here, but, as an example, a bath containing 300 grms. per litre of CrO_3 would operate well with 2·5 grms. per litre H_2SO_4.

The determination of the sulphate is difficult, but can be carried out by a barium sulphate precipitation, provided certain precautions are taken. Fortunately it is not necessary to do this often. The chromic acid is readily found simply by measuring the specific gravity of the solution with a Twaddell or hydrometer. Additions of chromic acid are made whenever the hydrometer shows that the solution has become impoverished to any appreciable extent.

The temperature for a given solution depends upon the current density. About 40° C. is usual. At this temperature, with a bath of above composition, bright plate would be obtained between the limits of 50 and 90 amps. per sq. ft.

Operation of the Bath.

When current is passing through the solution, a large amount of hydrogen is evolved at the cathode in addition to the chromium deposited. This hydrogen is necessary



to prevent the reoxidation of the chromium by the strongly oxidising solution before it is deposited in the metallic form on the cathode. At the same time, a part of the hexavalent chromium of the CrO_3 is reduced to trivalent chromium Cr_2O_3. This is very detrimental to the solution, and one of the most important functions of the anodes is to reoxidise this Cr_2O_3 to CrO_3. Whether or not this is possible will depend almost entirely upon the oxygen overvoltage of the anode material. Here we see the great difference between iron and lead anodes, the only two materials that have so far given any degree of satisfaction.

Lead anodes have a much higher oxygen overvoltage than those of iron; they give far better results, and do not dissolve rapidly in the solution. Although it is often said that iron has no serious effect in these baths, even when the amount dissolved is considerable, it always tends to increase the resistance of the solution and decrease the throwing

*Previous article in December, 1932, issue.

power. As in bright chromium plating the latter is always poor, every effort should be made to keep it as high as possible.

Anodes of antimonial lead are now being largely used, and appear to have advantages over the pure lead types. Pure lead is slowly attacked by the chromic acid forming lead chromate, which adheres to the anodes and unless removed frequently will have a bad effect on the cathodes, making the deposits patchy and devoid of chromium in certain areas. The antimonial anodes are not so subject to this trouble.

With the object of reducing the Cr^{III} to the minimum, most vats are now lead lined, this acting as an anode when necessary by connecting to the anode bars.

With regard to the cathodes, as the hydrogen overvoltage of chromium is high, the metal being covered should have similar characteristics. This explains why it is easy to chromium plate direct on to copper, whereas it is difficult to deposit upon steel because of its low hydrogen overvoltage. The overvoltage of nickel is not as high as chromium, but it is higher than that of iron and steel, and, as no better material is available, it is the best undercoating to use.

In all cases of bright chromium plating, success depends upon the quality of the undercoat. The thickness of the chromium is very small, a fraction of a thousandth of an inch, and unless the underlying metal is sound, corrosion troubles will soon arise. Chromium deposits are nearly always porous, and are very apt to have innumerable hair cracks running through them. The underlying metal is therefore readily exposed, and unless it is sound will soon be the starting point of corrosion.

Owing to the violent hydrogen evolution at the cathode during chromium plating, the deposits nearly always contain large volumes of occluded gas. This hydrogen is probably the cause of the extreme hardness of all these deposits.

The procedure in chromium plating an article is as follows: Having prepared a good nickel undercoat, the article is immersed in the chromic acid bath and a high "striking" voltage applied. This is maintained for perhaps 45 secs., and the voltage is then reduced to the normal value. For example, in plating upon nickel on steel, a "striking" voltage of 4½ to 6 would be used, reduced later to 3½ to 5 volts. As soon as the article is completely covered with chromium, which occurs during the "striking" period, the overvoltage of the underlying metal ceases to play any part in the operation; the influencing factor then becomes the overvoltage of the electrodeposited metal. The working voltage may then be reduced to the normal value.

As there is much spray evolved from the work when in the bath, this must be removed and the chromic acid recovered therefrom. The solution collected in the extractor can be returned to the vat from time to time. It is this spray and drag-out losses which make it necessary to determine the sulphate content of the vat periodically. Were it not for these losses the sulphate would remain substantially constant for an indefinite time.

When the articles are removed from the vat they are rinsed in water contained in an iron tank. This solution soon becomes fairly rich in chromic acid, especially if the vat is being worked continuously, and may, after a time, be added to the vat liquor to help to increase its chromium content.

When chromium plating solutions have been in use for some time there is always the danger of contamination by foreign elements. The effect of metals dissolving in the vat may not be apparent for a long time, and then quite suddenly the bath starts to give trouble. When the solution has become so contaminated it is almost impossible to do anything with it except to discard a part or all of it. As these solutions can easily cost 7s. 6d. per gallon, to throw away 200–300 gals. is rather a costly matter.

It is very important, therefore, to take precautions against such troubles. If any articles fall into the vat they must be removed at the earliest opportunity. Iron is perhaps the greatest cause of trouble in this respect. If the vat is working on iron and steel articles, and these are hung in the solution for a few seconds before the current is turned on, iron will be dissolved. The amount is very small, but as the effect is cumulative, it becomes serious in time. The curve given below shows how iron increased in a certain solution over a period of twelve months. In this particular instance the solution was used for approximately 1,000 ampere hours per week.

Results obtained from Chromium Electrodeposits.

Chromium is used to-day for plating all manner of different material, and it is interesting to see how the base metal affects the results obtained in practice. There is little doubt that, when the chromium is on copper, or nickel-plated copper, better results are obtained than when upon nickel-plated steel. This is possibly due to the fact that all work gets approximately the same standard of treatment, whereas actually the steel should receive a heavier nickel deposit than the copper. Provided sufficient care is taken with the nickel undercoat, there is no reason why a thoroughly good job should not be made of the finished article, one that will give satisfactory service for some years.

Prevention of Gassing.

Chromium will not deposit on any part of an article from which violent gas evolution is taking place. Thus, if an attempt be made to plate an article containing a number of holes, it will often be found that no metal has been deposited in the immediate vicinity of the holes. To overcome this trouble the holes and all similar apertures must be plugged. Corks are generally used and answer the purpose quite well. The same difficulty is apt to occur at sharp angles and corners, and it may be necessary to use shaped pieces of wood, so fitted that the angles are rounded off, and the gassing thereby minimised. For small work plasticene is often used.

The following table gives some chromium plating data :—

Metal.	Time in Vat Minutes.	Striking Voltage.	Running Voltage.	Current Density Amps./ Sq. Ft.	Temp. °C.
Steel, nickel plated (*a*)	15	6·0	5·0	70–80	40
Steel, nickel plated (*b*)	15	4·5	3·5	65	40
Direct on copper..	13	5·0	4·75	90	45

(*a*) = large articles. (*b*) = small articles.

Difficulties of Plating Complex Articles.

The throwing power of all bright chromium plating solutions is very poor; this means that it is difficult to get a deposit over the whole surface of articles of complicated shape. It is often found that in such cases the nickel is not covered with chromium in corners and recesses. Sometimes it is very difficult to see this defect, especially when viewing in artificial light. It is also possible for parts of the article, where the cathode current distribution has been too low, to have an extremely thin chromium deposit. In such circumstances the article may, when examined, appear to be quite sound, but unfortunately the defects show up only too soon when it is put into service.

To minimise this trouble, care must be exercised in arranging the anodes with respect to the work. For example, in plating inside a hollow article, such as a parabolic lamp reflector, good results can be obtained if an anode is hung inside, so that it faces the surface on which chromium is to be deposited. A little forethought will generally be of great assistance in this direction; it sometimes pays to have anodes of a special shade made for use in conjunction with plating of certain articles. This is an instance of a point which is so apparent in chromium plating, more so than in many other commercial operations, that success depends very largely upon the experience of the plater and on his care of and interest in the work.

Manganese, Its Ores, Properties and Uses

The greater part of the world's output of manganese ore finds outlet in the manufacture of iron and steel. A report on the subject of manganese, which is founded chiefly upon published information available, has been prepared by Robert Ridgway, from which the following information has been abstracted. The report is concerned primarily with commercial high-grade ores that contain an excess of 45% of manganese suitable for the manufacture of ferromanganese.*

MANGANESE is a common and widely distributed metal. It is very active chemically, and is found in many mineral forms. Like iron, it is dissolved out of the crystalline rocks, in which it is almost invariably present, and is redeposited as carbonate, oxide, or hydroxide. The more common mineral compounds are the oxides, carbonates and silicates. The manganese ores usually consist of a mixture of oxides, and are generally of secondary origin, either residual or sedimentary. Of the few bedded deposits known, those at Tchiaturi are the best example. Small amounts of carbonates and silicates have been mined for their manganese content in a few places. The chief ores are described briefly in the following :—

Pyrolusite (MnO_2, generally containing a little H_2O) forms the chief manganese ore. It has a metallic lustre, and varies from greyish black to black in colour. The mineral is soft, and will soil the fingers ; its hardness varies from 2 to 2·5, and specific gravity from 4·73 to 4·86. When pure, pyrolusite contains 63·2% manganese, but it is rarely found in the pure state ; usually it contains small quantities of silica, lime, iron, and barite. The ore usually occurs massive or reniform, occasionally with a fibrous or radiate structure ; sometimes it is found powdered or in small grains. The bulk of the Caucasian ore consists of pyrolusite.

Psilomelane (of uncertain composition, perhaps conforming to H_4MnO_5) is often associated with pyrolusite as an ore of manganese. It is iron black to dark steel-grey in colour, with a dull sub-metallic lustre. It can be distinguished from other manganese oxides by its hardness, which varies from 5 to 6. Specific gravity ranges from 3·7 to 4·7. It is amorphous, the common form being rounded or botryoidal masses, usually with a smooth surface. The content of metallic manganese ranges from 45 to 60%. It is often associated with small quantities of barite and potash. Psilomelane is the most abundant mineral in the manganese ores found in India.

Braunite (M_2O_3, $MnSiO_3$, the sesquioxide and silicate of manganese) is invariably associated with silica either mechanically mixed or chemically combined, in amounts up to 8 or 10%. It is a brownish or greyish black mineral with a sub-metallic lustre. The ore ranges in hardness from 6 to 6·5, and is frequently too hard to scratch with a knife. The specific gravity varies from 4·75 ot 4·82. Braunite, which contains 69% metallic manganese, never occurs pure in nature ; in ores it is usually associated with other manganese minerals, especially psilomelane. Braunite is a characteristic mineral in the manganese deposits of Arkansas, where it occurs with psilomelane.

Manganite ($Mn_2O_3.H_2O$, the hydrated sesquioxide) is sometimes known as grey manganese ore. Its colour varies from steel-grey to iron-black, with a sub-metallic lustre. Its hardness is 4 and its specific gravity 4·3. Manganite frequently alters to pyrolusite, from which it can be distinguished by its hardness and brown streak. Pure manganite contains 62·5% manganese. In the United States it is found mainly in California.

Hausmanite ($MnO.Mn_2O_3$) is a brownish black mineral with a dull metallic lustre. Its hardness ranges from 5 to 5·5, and its specific gravity from 4·72 to 4·86. The manganese content is 72·1%. It is one of the rarer oxides of manganese, but is widely distributed, and occurs with other manganese minerals. It is produced artificially by the sintering of carbonates and oxides.

Wad (impure hydrous mixture of oxides of manganese) is an amorphous, earthy, soft, friable mineral with a black or brown colour, and is commonly known as bog manganese.

Rhodochrosite ($MnCO_3$, carbonate of manganese) is a rose-pink mineral with a pearly lustre, and has a manganese content of 47·8% when pure. It has a hardness of 3·5 to 4·5, being easily scratched with a knife ; specific gravity ranges from 3·45 to 3·6. It is a comparatively rare mineral, and is usually found associated with other metals in vein deposits. It has been mined as a manganese ore in the French Pyrenees and at Butte, Mont.

Rhodonite ($MnSiO_3$, silicate of manganese) is a rose-coloured mineral with a vitreous lustre. Its hardness varies from 5·5 to 6·5, being somewhat greater than that of rhodochrosite ; specific gravity ranges from 3·4 to 3·68. The content of metallic manganese is 42%.

Bementite ($2MnSiO_3.H_2O$, the hydrosilicate of manganese) is a soft mineral, pale greyish yellow to brown in colour, with a pearly lustre. Its specific gravity is 2·9. It is a common mineral in the deposits in the Olympic Mountains, in the State of Washington.

Many other minerals contain varying amounts of manganese, but those just described represent the chief ores of manganese ; the two-silicates are of very minor importance.

World Sources.

Although the ores of manganese are widely distributed throughout the world, occurrences of large bodies of high-grade ore of commercial importance are limited at present to Brazil, British India, the Gold Coast, the Union of South Africa, and the U.S.S.R. The less important occurrences of high-grade ore include those of Algeria, Austria, Canada, Chile, China, Costa Rica, Cuba, Czechoslovakia, England, Italy, Japan, Mexico, Morocco, Netherland East Indies, New Caledonia, Newfoundland, Panama, Portugal, Puerto Rico, Rumania, Spain, Sweden, Tunisia, and the United States. Lower-grade ores (ferruginous manganese ores) are obtained chiefly from Egypt, the United States, Germany, France, Greece, Italy, and Australia.

World Production.

Although manganese has been used since the time of the Egyptians only a relatively small amount was produced up to the second half of the nineteenth century. During the early part of this period it was used as a decolorising agent in the manufacture of glass. Later in this period it found further outlets in the ceramic industry, and in the manufacture of chlorine. The first application of manganese in metallurgy dates from 1839, when Heath applied manganese compounds to the manufacture of steel. The use of manganese in modern metallurgy dates from 1856, when Bessemer invented the unique process of making steel which bears his name. The first ingots produced by this method in England were red-short and cracked or crumbled in the rolls. Mushet's suggestion of adding

* U.S. Bureau of Mines I.C. 6729.

spiegeleisen to the blown metal to ensure malleability while hot was tried successfully. This discovery established the Bessemer process of making steel, and from then on manganese became essential to steel manufacture.

At this time the higher manganese alloys used in steel manufacture were made by the crucible process, and were expensive. The increasing production of steel created a demand for cheaper manganese alloys, and as a result the smelting of spiegeleisen and ferromanganese directly from ores in a blast furnace was developed by Pourcel and others in France from 1875 to 1885. The price of high manganese ferro-alloys was thus greatly reduced and consumption increased greatly. This, in turn, led to an increased demand for high-grade ores. Fortunately, this demand was satisfied by the discovery and exploitation of large deposits in Russia (1879), British India (1892), and Brazil (1894). In 1899 world production of manganese ore exceeded 1,000,000 long tons for the first time, and has since increased to 3 440.000 tons in 1930.

Properties of Manganese.

Manganese is a crystalline, brittle metal, silvery-white or greyish-white in colour, with a reddish lustre. The specific gravity varies from 7·05 to 8·01, depending on the sample. Its atomic weight is 54·6; melting point, 1,244° C.; boiling point, 1,900° C.; electric conductivity as compared with silver, 1 to 55. Several different allotropic forms of the element are known to exist. To a sodium carbonate bead in an oxidising flame, manganese imparts a characteristic bluish green colour; to a borax bead in an oxidising flame it gives a purplish or amethystine colour. Its chemical properties are similar to those of iron. It oxidises readily and consequently is never found in nature in the metallic state.

Metallurgical Uses.

Although manganese ore is consumed in both the ferrous and non-ferrous industries, the bulk of the world's output finds outlet in the manufacture of iron and steel. Various estimates indicate that more than 90% of the world's consumption is in the ferrous metallurgical industry. Most of the manganese ore entering this field is used in the making of ferro-manganese and spiegeleisen, the forms in which manganese is usually added to steel. These two alloys of iron, carbon, and manganese have the following composition :—

	Ferromanganese, %		Spiegeleisen, %
Manganese	78–82	..	18–22
Iron	8–15	..	70–80
Silicon	0·5–1	..	1
Carbon	5–7	..	5–6
Phosphorus	0·1–0·3	..	0·15
Sulphur, less than	0·03	..	0·05

Silicomanganese and silicospiegel are used in certain grades of steel, and may replace ferro-manganese and spiegeleisen. The usual requirements, as to analysis, for these two alloys are :—

	Silicomanganese, %		Silicospiegel, %
Manganese	55–70	..	20–50
Iron	5–20	..	43–67
Silicon	25	..	4–10
Carbon	0·35	..	1·5–3·5

Considerable manganese ore is also added to the pig-iron blast-furnace charge when the iron ore burdens are deficient in manganese, especially when the pig iron is required for steel-making processes.

Under present technology the use of manganese is indispensable in the manufacture of steel, where it is used to improve blast-furnace operation and to offset the harmful effects of oxygen and sulphur. It is used not only in the process of making plain carbon steel, but also as an alloying constituent because of certain properties it imparts to alloy steels. Manganese steels are utilised in the manufacture of plates, shapes, structural bars, open-hearth rails, spring steels, car wheels, tyres, axles, and for many other purposes where toughness and resistance to abrasion are required. Some manganese is also used in foundry work.

The greater part of the manganese ore mined is used in the manufacture of ferro-manganese, either in the blast-furnace or in the electric furnace. In the process virtually all of the iron and phosphorus in the charge enters the resultant alloy. Consequently, the usability of the ore depends on the ratio of manganese to iron and on the phosphorus content. The initial requirement of manganese ore is that the ratio of manganese to iron should be about 10 to 1; so that, allowing for normal loss from 12 to 18% in the total manganese, the ratio of manganese to iron in the alloy may be maintained. Silica above 8% makes ferro grade ores undesirable.

Fine and soft ores are particularly objectionable in blast-furnace practice, as they impede the blast and cause loss as flue dust. Hard ore in medium-sized lumps is desired, so that the weight of the charge may be sustained without breakage.

Much lower grade ores are used in the manufacture of spiegeleisen and pig iron with a relatively high manganese content. Large quantities of ore containing from 2 to 5% of Mn are consumed largely in the manufacture of basic open-hearth pig. The combined iron and manganese content of such ores, however, should be about 50%.

Manganese is also used in the formation of alloys of copper, zinc, aluminium, and other metals. Manganese ores have also been used for fluxing in non-ferrous smelting operations.

That there is no extensive use of pure or nearly pure metallic manganese is due in part to the difficulties and high cost of producing the metal. It is consumed largely for experimental purposes.

Chemical Uses.

Although the greater part of the production of manganese ore is consumed in the metallurgical industries, many valuable and growing applications of this raw material are found in the chemical industries.

Dry-cell Manufacture.— Probably the most extensive chemical use of manganese ore is in the manufacture of dry cells, in which the function of the manganese dioxide is that of a depolariser. Manganese dioxide used for this purpose should have a high content of available oxygen with minimum iron and be comparatively free from metals, such as arsenic, copper, nickel, or cobalt, which are electronegative to zinc. The physical properties of the oxide are important. The material should be porous and moderately hard.

Glass Industry.— Another outlet taking advantage of the oxidising power of manganese dioxide is in the glass and ceramic industry. Most of the sand used in these industries contains iron which imparts a greenish tinge to the glass. The available oxygen of the manganese dioxide converts the greenish salt into the nearly colourless salt, while the slight pink tint imparted by the manganese salt is complementary to the bluish colour of the oxidised iron. Fine glassware is almost entirely decolorised by the addition of manganese dioxide. The quantity of manganese dioxide used varies from 2 lb. to 15 lb. per 1,000 lb. of sand, depending on the character of the glass, the method of its manufacture, the iron content of the raw material, the character of the manganese ore used, and the temperature at which the glass is made. Wad, the earthy variety of manganese oxide, is used in conjunction with other oxides in this industry. High-grade ores with a small iron content are required for this trade, although siliceous pyrolusite is not objectionable.

Paint and Varnish Driers.— Manganese compounds are used extensively as driers in the preparation of varnish and paint, due to their catalytic properties. The manganese compounds used are natural and artificial manganese dioxide, manganese hydrate, borate, chloride, sulphate, resinate, linoleate, oxalate, and other salts. Manganese ore required for this use must be of relatively high grade.

Pigments and Dyeing Materials.—Manganese compounds are used in colouring glass, pottery, tiles, and brick; in calico printing and dyeing; and for certain paints. The principal manganese compounds which are used in the colour industry are manganese white ($MnCO_3$), manganese green (manganous oxide), manganese violet (manganese metaphosphate), and manganese black (pyrolusite). Wad is used as a constituent of umber paint. Manganese hydroxide and sulphate are used as colours for porcelain, and also for the dyeing of textiles. Manganese chloride is used for dyeing cotton to manganese brown or bronze, and also in calico printing.

Fertiliser.—Manganese plays a very important part in plant and animal nutrition. The use of manganese in agriculture has been increased in the last few years as a result of some practical demonstrations with truck crops in Southern Florida. Most soils contain sufficient manganese for profitable crop production, but in certain sections where manganese is rare in rocks and soils serious difficulties are experienced. The addition of small quantities of manganese sulphate rendered such land productive to crops previously considered failures.

Miscellaneous.—Manganese ore is used in the manufacture of iodine and chlorine, but the expansion of the electrolytic process for the production of chlorine has caused a decline in the demand for manganese dioxide for this purpose. Various salts of manganese are used in disinfectants, deodorisers, sterilising agents, flotation agents, fluxes, medicinal reagents, photographic reagents, and for impregnating leather. The manufacture of the manganates and the permanganates for use as germicides and deodorisers is now an important branch of the chemical industry. The permanganates are also used for the preservation of timber, bleaching of textile fabrics, and as an oxidising agent in the manufacture of organic compounds.

Value of Manganese Ore in World Trade.

Of the major steel-producing countries, only Russia has within its national boundaries sufficient manganese ore to supply its needs; all other countries must depend upon imports for their requirements. Consequently, manganese ore is an important strategical commodity in world trade. During the war and immediately after there was a threatened shortage in the supplies of manganese ore due to the restrictions on shipping and later to revolution and internal disturbances in Russia. High prices prevailed during this period. Later, the establishment of more settled conditions in Russia and the advent of new low-cost producers resulted in increasing the supply so that there is now in normal times an oversupply, and sufficient reserves are in sight to ensure consumptive industry of an assured supply. Prices declined with the increasing supply.

While there is some small trade in the carbonates and silicates, the principal ores marketed are the oxides. The character of the oxide determines the purpose for which it is used—whether metallurgical or chemical. Metallurgical ore should have a high manganese content (from 45 to 50% and a low content of silica, oxygen, and phosphorus; it may be high in lime. Chemical ores should be high in oxygen, may contain considerable silica and phosphorus, but be low in lime.

The Heat-treatment of Hiduminium Alloys

Heat-treatment technique varies according to the particular alloy to be treated; with aluminium alloys it is of vital importance to use the most suitable, and the treatment recommended for Hiduminium alloys is given.

THE heat-treatment of aluminium alloys is a relatively recent operation, but so much progress has been made since it was discovered that certain types of alloys could be manipulated in a similar manner to steel that at the present time the operation is more highly developed than with other non-ferrous metals. Investigations have shown the precise heat-treatment necessary to give the properties most desired, but since the composition of a particular alloy determines the technique involved it is of vital importance to use the most suitable heat-treatment. In the case of special alloys, such as the "Hiduminium" alloys, which have been developed for high duty purposes, the recommended heat-treatment technique for sand and die castings in R.R. 50 alloy is to heat them in a well-regulated oven to a temperature of 160° C. to 170° C. for 10 to 20 hours, according to size or bulk, and quench out in cold water or cool off in still air.

Sand and die castings in R.R. 53 alloy should be heated to a temperature of 525° C. to 535° C., maintained for 2 hours, and quenched off in water over 70° C. Then they should be heated to a temperature of 300° to 350° C., and subsequently heated up slowly to the quenching temperature. Treatment of castings with widely different variations of sections needs additional care to prevent cracking or distortion due to differential contraction. Cylinder heads, for instance, with thin fins and heavy wall sections, should be allowed to cool in the air for 1–2 mins. after removal from the bath or furnace before quenching, in order to obviate this danger.

In the treatment of forgings and stampings in R.R. 56 and 59 alloys the parts should be warmed thoroughly and then placed in a furnace or molten salt bath at a temperature of 300°–350° C., and the temperature slowly increased to 525°–535° C. and maintained at this temperature for a period of 2 hours and quenched off in water over 70° C. Then heat in a well-regulated gas oven or electric furnace to a temperature of 165° to 175° C., and maintain for 15 to 20 hours and quench off in cold water.

As an alternative to the latter treatment, the parts can be heated to 200° C. and maintained for an approximate period of 2 hours, and quenched off in cold water. This treatment, however, needs very carefully regulating to obtain the correct period of soak according to the size of the part. It is advisable to have the gas oven or electric furnace at a temperature of 200° C. before loading the parts. The temperature will naturally drop and then slowly rise again to 200° C. When this temperature has been attained and the parts are uniformly heated throughout, the stipulated period of 2 hours is then given and the material quenched off. Large forgings, such as Diesel engine pistons with 4 in. to 5 in. crown, should be gradually quenched, the crown being allowed to remain in the water for 1–2 mins. before finally immersing the whole piston.

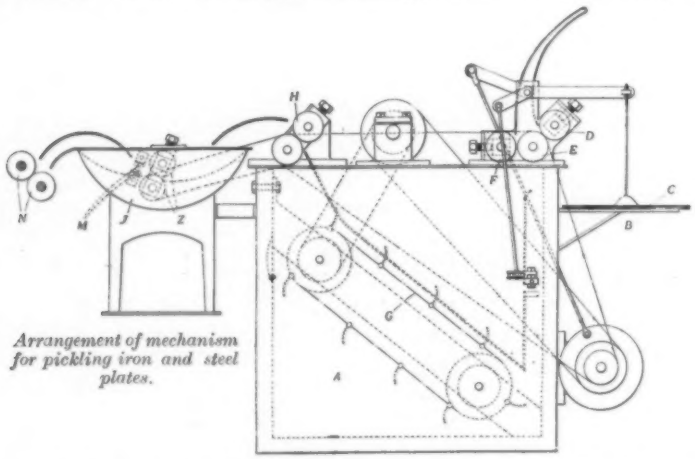
Castings in Hiduminium "Y" alloy, particularly those of intricate design and change of section, should be thoroughly warmed up before placing in the salt bath or electric furnace, the temperature of which should be about 300° C. The temperature of the bath or furnace is then slowly increased to 510°–520° C. and maintained for a period of 2 to 3 hours, according to the size and bulk of the castings, and the parts then quenched off in boiling water. The castings are allowed to remain in the water until reasonably cool—say, 2 to 3 hours. In the case of forgings, these should first be warmed thoroughly and then placed in the bath or furnace at a temperature of 300°–350° C., and the temperature slowly increased to 510° C. and maintained at this temperature for a period of 2 hours, then quench off in boiling water. The forgings should be allowed to remain in the water until they have cooled off—at least 2 to 3 hours. It is very important that the quenching water for "Y" alloys must be boiling.

Some Recent Inventions.

The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

Pickling Iron and Steel Plates.

MANY methods have been devised with the object of simplifying the process of pickling iron and steel plates in conjunction with a pickling vat. In one device a sucker member co-operates with rolls to feed plates singly from a pile of plates to a conveyer constituted by a pair of rails with projections which engage the rear edges of the plates and ensure their forward movement. In another arrangement the pickling vat having fed rolls with an endless conveyer band having fingers and co-operate with parallel guides, the lower and forward travelling flight of the conveyer band being located within the vat, and the upper and return flight being positioned above the vat. In some instances the plates are conveyed through the vat on spaced guide bars by movable arms timed in relation with sucker member and feed roll mechanism arranged to deliver plates singly from a pile of plates. Recent improvements have been made which apply particularly to the manufacture of tin plates. In these the apparatus includes in association with a pickling vat mechanism for lifting the plates singly from a pile, feed rolls for transferring the plates from the lifting mechanism to the vat, an endless chain or belt conveyer operating within the vat to transfer the plates to delivery rolls, and a gate or movable guide-plate timed to operate in relation to the lifting mechanism to guide the plate to be pickled into the path of the conveyer.



Arrangement of mechanism for pickling iron and steel plates.

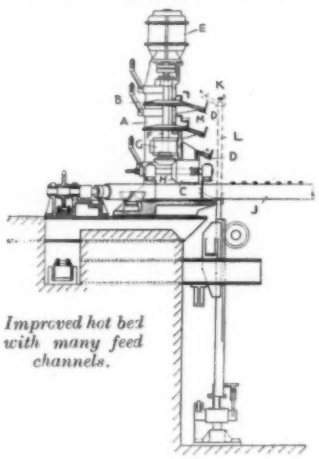
The lifting mechanism includes a sucker plate-lifting member, three parallel adjacent rolls and a curved guide, so designed that the plate is fed between a pair of rolls into the guide and delivered through a pair of rolls to the vat. The endless conveyer may be placed entirely in the vat. The conveyer conveys the plate through the vat into the path of delivery rolls which may deliver the pickled plate into a swilling bath. Beyond the swilling bath may be located a tinning bath into which the swilled and brushed plates may then be passed.

This arrangement is shown diagrammatically in the accompanying illustration, which shows a pickling vat provided with the improved means by which plates may be separately pickled in association with a swilling bath. In the drawing A refers to the pickling vat on which is mounted a support B for the plates C, which are arranged in a pile. D, E, F indicate feed rolls by which plates are delivered to the vat. G indicates a conveyer operating within the vat and serving to convey the plates deposited from the rolls E, F on an inclined grating arranged to falilitate the delivery of plates to rolls H. Adjacent the delivery rolls is shown a swilling bath J to which the plates are delivered. In the swill-bath are disposed rolls Z and brushes M between which the plates pass in succession. The rolls at N are mounted on the walls of a tinning pot, and the pickled and swilled plates are fed between these rolls and delivered to the tinning pot.

385,725. BENJAMIN A. THOMAS, Griffith Terrace, Sketty, Swansea, Glamorganshire. January 5, 1933.

Hot Bed with many Feed Channels.

THE design of the feed channels in a hot bed, when they consist of discs one above the other, is not suitable for rolled bars of large cross-section, especially when in the form of sections, angles, channels, and the like. To render the apparatus suitable in such cases, the superposed discs are supplemented by roller trains, the rolls of which are disposed horizontally and are also provided with collecting rests for the rolled bars that are to be removed. The arrangement is illustrated in the accompanying sketch, in which A represents the disc frame and B the superposed discs. In addition to the discs a train of rollers C is provided. As with rotating discs, these rollers are provided with rests D to catch the oncoming rolled articles. The rollers are driven by the motor E by means of the shaft F carrying the rotating discs mounted at G below the bottom disc B. Motion is transmitted to the rollers through pairs of friction-wheels H or by toothed bevelled pinions. The "hot bed," consisting of obliquely mounted rollers, is shown at J.



Improved hot bed with many feed channels.

In this arrangement the rods are lifted out of the rests D by means of an angle iron K, which is capable of swinging about a vertical axis and is mounted on the thrust rod L, which is adapted to rise and fall axially and is also rotatable. The guide-strips M for the rolled articles are adapted to be alternately moved out of the blocking position and are angular in form, the upper limb serving as a cover, thus preventing the oncoming rolled rods from going astray.

As designed, this apparatus is intended for use in delivering the rolled rods selectively—according to the rolling sequence of operations—either on to the train of horizontal rollers or on to the discs.

387,109. DEMAG AKTIENGESELLSCHAFT, Duisburg, Germany. February 2, 1933.

Improved Process of Welding

IN those processes in which the additional metal is cast around or between the parts to be welded, particularly in the case of steel rails when the temperature of the joining metal is about 1,500° C., the properties of the melted metal are relatively weak, and when the welding has been accomplished the rail lacks continuity of resistance to normal stresses in the zones adjacent to and through the weld. A process recently developed is claimed to overcome this difficulty despite the lack of homogeneity of the various zones formed by metals the composition and

(*Continued on page* 130.)

Shipping, Engineering, and Machinery Exhibition

It is a happy augury for the success of this exhibition that a distinct improvement is visible in trade and industry. Leaders are more optimistic, and the prospects of a gradual recovery are bright. There will be much of interest at this exhibition, and advance information indicates that a large number of people, not only from provincial centres, but from overseas, will take the opportunity to keep in close touch with progress by making one or more visits.

THE organisers of the Shipping, Engineering, and Machinery Exhibition, which commences at Olympia on September 7 and remains open until September 23 are to be congratulated on the efforts made to assist in trade and industrial recovery by staging this exhibition. The last exhibition under similar auspices was held two years ago when the depression seemed to be at its worst, and the conditions were naturally against the degree of success the effort deserved; on this occasion, however, there is a spirit of hopefulness abroad that augurs well for the success of this exhibition. Without being too optimistic, industry shows a degree of improvement that may be regarded as an indication of a gradual recovery in trade. Everyone will appreciate the need for an impetus to shipping, engineering, and machinery at this time, and although industry is at a relatively low ebb, developments have been made that cannot fail to have the utmost value to all interested in these fields. In this article it is only possible to refer to a limited extent to the progress achieved, and readers are advised to take an opportunity of making a personal visit.

As may be expected, marine engineering in many forms and types is well represented, various types of Diesel engines will be shown by some of the foremost builders in this country; the latest developments in steam-turbine construction, too, will attract considerable attention. Probably the most interesting of the marine exhibits are those shown by Babcock and Wilcox, Ltd. These comprise a full-size section of a standard boiler, four tube sections wide, fired with an Erith-Roe stoker, one retort wide, in a furnace of Bailey construction. This exhibit will be complete with steel casing on side, front, and rear, Babcock calorised diamond soot blowers, and Babcock-Clyde blower, baffles, mountings, and refractory where necessary. The stoker will be in motion, and the height of this equipment will be approximately 15 ft. from floor to centre of drum. A second exhibit will be a full-size section of the Babcock and Wilcox "S.X." type marine boiler. It will be two sections wide, and will be set over an oil-fired furnace of imitation refractory construction, a standard pressure type sprayer will be installed in the wall under the lower horizontal header, and in the opposite wall will be installed a Babcock-Clyde single nozzle blower. This exhibit will be complete with steel casing, and such mountings and auxiliaries as are applicable will be incorporated. The "S.X." boiler is the latest design of small tube, light-weight boiler by Babcock and Wilcox, and results achieved indicate that it provides a distinct step forward with regard to high efficiency over a wide range of load. A third exhibit will be a full-size corner section of a Bailey hopper bottom pulverised fuel furnace; this will measure approximately 20 ft. from floor to top headers.

In view of the number of recent orders received, the combination of the Babcock boiler and the Erith-Roe stoker will receive considerable attention, as it is apparently finding general acceptance as equipment for the latest coal-burning steamships. It is probable, however, that the desire for high efficiency over a wider range of load will find a marine field for the Bailey furnace which has been adopted so widely for land use.

Various models of Parsons' well-known marine steam turbines will be on view, some of which will be working. These will include a working model of this firm's latest "Simplex Unit" system for cargo boats. In this instance the model will be arranged so that the turbine blading, gear-wheels, etc., can be inspected. The propelling unit will consist of two turbines working in series—high pressure and low pressure. For a power of 2,000 s.h.p. (equivalent to 2,200 i.h.p.) at 75 revs. of propeller shaft, the weight of the complete unit is estimated at 56 tons. With a boiler pressure of 275 lb., temperature 750° F., vacuum 28½ in., the steam consumption is 8 lb. per horse-power hour. This model should prove of great interest to all shipowners,

Typical casting in "Hypocrode," by Sheepbridge Stokes Centrifugal Castings Co., Ltd.

shipbuilders, and marine engineers. There is also shown a comprehensive collection of Parsons' turbine blades in various materials in individual or assembled form.

Probably the widest range of exhibits will be displayed by Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd. These will include Diesel electric traction units; pneumatic tools; Spencer-Hopwood water-tube vertical boilers; and non-crucible melting furnaces are also expected to be on view. A 150-ft. runway track will be laid on the stand in order to demonstrate one of the range of shunting locomotives. Although not new, this particular type of locomotion is a comparatively new development in this country, and will create much interest. The "Spencer-Hopwood" boiler exhibit has not yet finally been decided upon, but it is certain that whichever size is selected from the comprehensive range, the unique features associated with these boilers will be clearly apparent to potential buyers of this type of plant. Special note should be made of the latest range of rotary air grinders, which mark an entirely new departure from the older reciprocating piston type machines. These new grinders have a cutting speed of approximately four times that of the older type,

and a free speed, according to size, from 6,500 r.p.m. to 12,300 r.p.m. Pneumatic chippers will also come in for a good deal of attention; these vary in size from the small "Pigmy" weighing approximately 6 lb., to the larger "Plus" type chippers for heavier work.

The development of ferrous and non-ferrous alloys, which are not only strong and hard, but at the same time are tough, ductile, resistant to shock and impact, and possessed of good impact values, have had a considerable influence in the progress shown by the various exhibits. Recent developments in alloy steels, for instance, have led to their wider application for constructional and engineering purposes. In marine engineering it will be noted that there is a growing use for alloy steels, not only for gearing, turbine parts, condenser tubes, etc., but also for many parts in heavy oil engines; while the production of heat-resisting steel and alloys, and the super-hardening of steel, have special applications.

Ferrous and Non-Ferrous Metals and Alloys.

In view of the stresses to which modern engineering structures are subjected, under varying conditions of service, considerable attention is being directed to the raw

A range of die-castings in a variety of alloys by Fry's Diecasting, Ltd.

materials employed, and invariably all the metals used are supplied to rigid specifications and subjected to careful investigation in order to ensure reliability in the finished structure. Thus, the exhibits of Bradley and Foster, Ltd., will warrant special attention. These will comprise a comprehensive range of samples of refined pig iron, and will be divided into four main groups—viz., blended all-mine pig iron, degasified cylinder pig iron, refined alloy pig iron, and refined malleable pig iron. The all-mine quality is produced on a basis of mechanical strength properties, and special methods are employed by which the iron can be made with known and regular physical and mechanical strength to suit any required tests. The cylinder iron is produced by a patent process, and ensures a completely homogeneous mixture, free from gases and slag particles, thus facilitating the production of cylinder castings of high strength. Foundrymen will be particularly interested in the alloy irons which will be exhibited, covering a wide range of qualities from low nickel chrome irons for direct use up to various types of austenitic ingots. A selection of castings from the alloy irons will be a noteworthy exhibit. The elaborate system of grading refined malleable pig iron by this firm will be demonstrated by a complete range of fractures.

Representative examples of Midhill" and 'Gledhill" all-mine special pig irons will be exhibited by British Pigirons, Ltd., together with fractures, test-pieces, micro-photographs, etc. These brands of pig iron are produced in cylinder, chilling, and special foundry qualities, and owing to the diversified analyses of the stocks carried, the firm is able to give prompt delivery of pig iron to almost any specification in these grades. It should be noted that these are blast-furnace products, and are not refined or subjected to any secondary heat-treatment.

Typical components in special alloy cast irons manufactured by the centrifugal process of casting, where cylindrical shapes are required, or as sand castings for more complex shapes, will be exhibited by Sheepbridge Stokes Centrifugal Castings Co., Ltd. The more important of these special irons include "Centrard (nitrogen hardened) for abrasion and corrosion resistance. Brinell hardness, 900 to 1,000; "Hypocrode," for corrosion and heat resistance; "Centricast Mark II" chrome alloy, for wear resistance, suitable for oil-hardening where thin sections are required; "Centricast Mark IV" nickel chrome alloy, for wear resistance and high strength, suitable for oil-hardening, where thick sections are required; "High Silicon," for acid resistance. This firm is licensed to manufacture "Nicrosilal" and "Silal" under British Cast Iron Research Association Patents 378,508 and 323,076 respectively. The former has been developed more particularly for scale- and heat-resisting. It is an austenitic cast iron, with a tensile strength of 14 tons per sq. in., and is suitable for parts exposed to extreme heat, such as furnace parts, burners, firebars, annealing, carburising and tempering boxes, chain-grate stoker parts, cyanide pots, etc. It is suitable for parts which may be used at temperatures up to 1,100° C. Silal is also applied to parts exposed to heat. It has a high silicon content, and may be profitably used for temperatures up to 950° C. "Hypocrode" alloy cast iron, castings from which will be exhibited, is essentially austenitic in character, and its main properties include resistance to erosion, scaling, and corrosive action of acids and alkalis; high coefficient of thermal expansion; resistance to distortion under heat conditions; non-magnetic, and resistance to growth at high temperatures. For most purposes this alloy contains 12 to 15% nickel, 6 to 7% copper, and 1·5 to 5% chromium; its tensile strength is 14 to 16 tons per sq. in.

A representative display of various types of condenser tubes will be exhibited by the Birmingham Battery and Metal Co., Ltd. Tubes in cupro-nickel, as supplied to the British Admiralty, and in aluminium brass, similar to those supplied to steamship companies and power stations for service under exceptionally bad water conditions. Aluminium brass condenser tubes have special qualities which render them highly resistant to the effects of corrosion, and are now claimed by the makers to be recognised by engineers as the condenser tube with the longest life. An exhibit of condenser tube plates and ferrules will also be found of interest. The company will also display solid drawn brass and copper tubes, from 24 in. diameter downwards. This company is also a large producer of hot- and cold-rolled copper sheets and plates, brass sheets, rolled, drawn, and extruded copper and brass rods, brass and copper strip, wire, etc, a selection of which will also be exhibited.

Solid drawn tubes in brass, copper, aluminium, cupro-nickel, aluninium-bronze, "Yorcalbro" and phosphor-bronze will also be exhibited by the Yorkshire Copper Works, Ltd. "Yorcalbro" condenser tubes will attract attention; they are formed from an aluminium bronze alloy, and have now become standardised for marine and land condensing plant.

Of considerable interest in the non-ferrous field will be the exhibits of J. Stone and Co., Ltd., who are well known

as manufacturers of large bronze propellers, in addition to the "Stone" system for controlling bulkhead doors. Many specialities will be displayed by this firm, but none will have greater interest than the non-ferrous metals for which they have been renowned for over a century. Some useful technical data in regard to these metals, compiled from tests carried out in this firm's metallurgical laboratory, will undoubtedly prove of interest to all visitors. Of equal interest will be the data they will be able to supply in regard to the performance under severe working conditions of the various white metals they make for different types of engine bearings, etc.

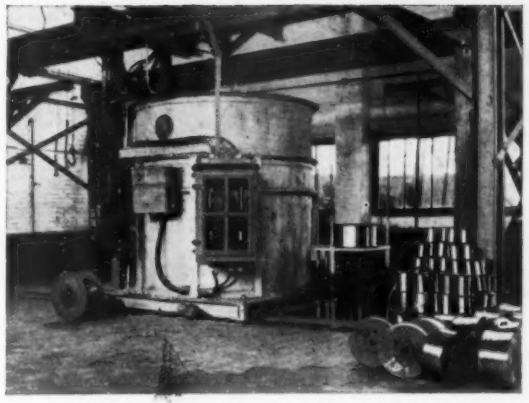
A full range of Telcon metals, including Pyromic, the 80/20 nickel-chromium alloy, and Calomic, nickel-chromium iron alloy, will be exhibited by Wild-Barfield Electric Furnaces, Ltd. These materials are used for heating elements, resistances, and similar products.

Reference to non-ferrous alloys would be incomplete without including the exhibits of anti-friction alloys manufactured by Fry's Metal Foundries, Ltd. An interesting selection of this company's many grades of white anti-friction metals, solders, mould metals, and chill-cast phosphor-bronze will be shown, and their inspection will prove of value to possible users.

With the development of improved technique in the production of die-castings, there are few industries that cannot make profitable use of castings produced by this process. Even complex parts are produced with comparative ease, and the degree of accuracy, in a wide range of metals and alloys, is almost unbelievable to the uninitiated. Whether die-castings have special interest or not, visitors should see the exhibits of Fry's Diecastings, Ltd.; their intricacy, finish, and accuracy will provide an agreeable surprise. With the aid of modern knowledge and craftsmanship practically anything can be die-cast, but experience has shown that design detail plays a controlling part in production cost and efficiency, for this reason it is advisable to remember that the die-caster can frequently overcome the problems of the bulk producer if he is consulted in the early stages.

The exhibits show advances resulting from the use of new and enlarged equipment, this together with improved technique has provided a greater variety of die-castings in the highly improved zinc base alloys, as well as the full range of aluminium alloys, aluminium bronzes, and high-duty copper-rich alloys. Visitors will be able to see the results of the new hydro-pneumatic, for which Fry's Metal Foundries, Ltd., hold the British Empire rights. This machine uses two sources of motive power—water and air,—both under pressure, and in its present form it is claimed to give the highest possible pressure, together with the speed and resilience which are so essential. One great advantage derived from the use of this new machine was the inclusion of the yellow metals in the available alloys for pressure production. But in addition, it is interesting to note that die-castings in aluminium alloys and zinc-base alloys produced by this process have a solidity and smooth finish claimed to be unequalled by any other method. Those who are sceptical should take the opportunity to submit the exhibits to a very close scrutiny. The outstanding properties of aluminium bronze, particularly in regard to corrosion resistance, are finding increasing applications in the form of die-casting, and those familiar with the initial results in the production of die-castings from this alloy will be able to determine the extent of the progress resulting from improved technique.

Die-castings by the gravity process will also be exhibited by Non-Ferrous Die Casting Co., Ltd. These will comprise castings in aluminium L.8; aluminium-silicon 2 L.11, 3 L.5, etc.; brass NF.PR. naval brass; aluminium bronze, NF.PZ. Die-castings in P.M.G. by special arrangement with Vickers-Armstrongs, Ltd., also in Barronia and Berdo, by special arrangement with Barronia Metals, Ltd., white metal, etc. Pressure die-castings in aluminium alloy; zinc base alloy; special high tensile zinc and tin alloy. Doehler



Bright annealing furnace for copper wire by Birmingham Electric Furnaces, Ltd.

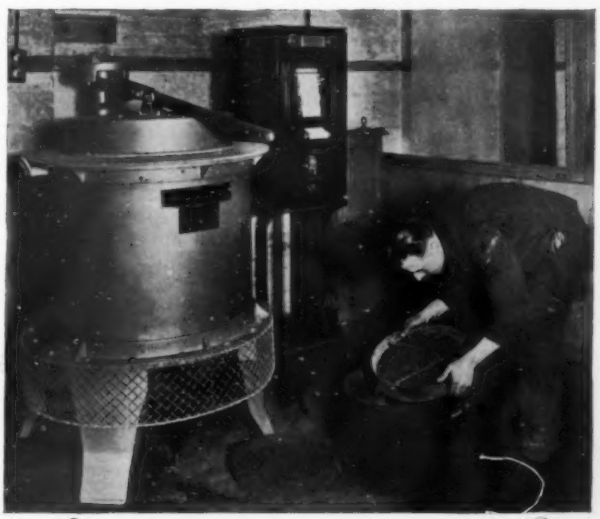
brass and bronze castings. Sand castings in most of the non-ferrous alloys. Hot stampings in the usual yellow metals and in NF.PZ and NF.PR. Special pressure castings in tin and zinc alloys of very small and intricate parts, including counter wheels under the Thormann process. Special Note.—Two special metals NF.PZ., U.T.S., 40 tons per sq. in., elongation on 2 in. 11% Brinell 180 and NF.PR. U.T.S., 30 tons per sq. in. elongation on 2 in., 19%. Brinell 133, are of special interest, as this material has very excellent bearing qualities.

Aluminium gravity die-castings for all trades in standard and special alloys including "Coanailium," will be exhibited by Robert W. Coan, Ltd. "Coanailium" is a special corrosion-resisting alloy for sea and climatic conditions; it also has great strength and durability. Test-pieces which have been subjected to sea tests will be on view.

Heat-treatment Furnaces.

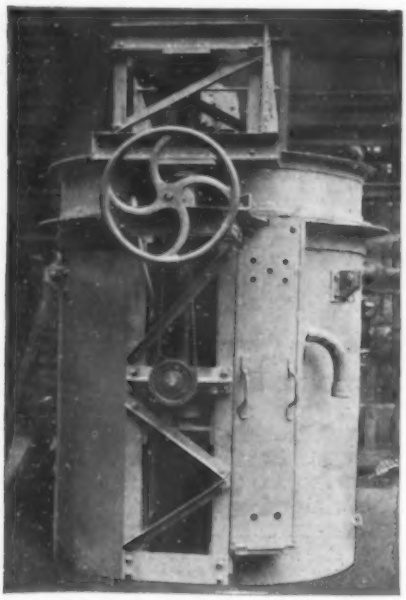
The profitable application of many ferrous and non-ferrous alloys depends upon heat-treatment, and only as a result of accuracy and control of the treatment can the desired properties be obtained on a production basis. In order to keep abreast of the needs of the engineer special attention has been concentrated on heat-treatment furnaces. Perhaps the most important development in this field since the last exhibition of this kind is that incorporating a system of forced air circulation in furnaces. During the two years that has elapsed experimental and research work has enabled modifications in design to be made which

Furnace with forced air circulation for low-temperature operations by Wild-Barfield Electric Furnaces, Ltd.



increase the output by no small amount. Particularly is this the case with electric furnaces exhibited by Birmingham Electric Furnaces, Ltd., Electric Resistance Furnace Co., Ltd., and Wild-Barfield Electric Furnaces, Ltd. and G. W. B. Electric Furnaces, Ltd.

The forced air circulation furnace exhibited by Birmingham Electric Furnace, Ltd., is designed for operation at temperatures up to 700° C., and the essential principle of the design is the heating of the charge by the forced circulation of heated air, direct radiation from the heating elements being prevented by a metal baffle. It is a known fact that heat transference is dependent mainly on convection, radiation taking little part at temperatures below about 500° C. A patented centrifugal fan is employed to increase the natural rate of convection many times, this type of fan having been found to circulate a great quantity of air under conditions such as obtain in a charged furnace—*i.e.*, where there is appreciable back-pressure. The work is charged into a cylindrical work-basket which is lowered into the furnace, where it is surrounded by the metal



Large furnace with forced air circulation by Electric Resistance Furnace Co., Ltd.

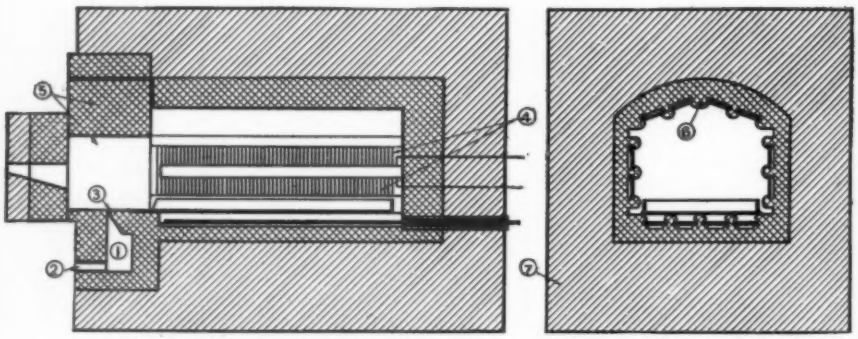
cylinder or "container" which forms the radiation-baffle referred to above.

A combined automatic temperature controller and charge progress recorder is associated with this furnace, which operates from two thermo-couples, one placed in the stream of hot air leaving the heating elements, and the other in the path of air which has passed through the work. The instrument gives a distinctively marked record of the temperature at each respective point on a single chart, and the coincidence of the two records indicates that the charge has ceased to abstract heat from the air and is heated through.

Another furnace of this type which has been designed with a view to improving the uniformity of temperature distribution and increasing the rate of transfer is exhibited by the Electric Resistance Co., Ltd. The application of high-speed fans has enabled a forced circulation of the furnace atmosphere, with more efficient results. This company recently supplied one of the largest furnaces of this type yet built. It is rated at 66 kw., and has an effective working chamber, 4 ft. 6 in. deep × 3 ft. 6 in. diameter. The fan impeller used is of the patented Gill screw type, and is located in the lid of the furnace. The advantage of this type of fan is that it is less sensitive to changes in pressure resulting from resistance to the passage of air by the charge.

A full production type of Wild-Barfield furnace with forced air circulation, complete with the Wild-Barfield-Foster charge progress recorder, will be in operation. These large production equipments are used for all heat-treatments requiring temperatures up to 700° C., and tempering, secondary hardening of high-speed steels, heat-treatment of aluminium alloys, and other non-ferrous materials are thus covered by this range. A smaller type is introduced for the first time. This equipment, whilst incorporating all the main features of the production model, is smaller and has simplified equipment, and is designed primarily for tempering carbon steels, and secondary hardening of high-speed steels in tool-room work. The whole unit is mounted on one framework, making a compact and convenient design. As a high output is not required in such a furnace, the charge progress recorder is omitted.

Besides the model previously mentioned, two furnaces employing the "Birlec" patent "Certain Curtain" method of atmosphere control in its latest improved form will be seen in operation. One model employing non-metallic heating elements is designed for operation at temperatures up to 1,400° C. for such purposes as high-speed steel hardening, Wimet tipping, etc., while the other is suitable for preheating high-speed steel, hardening carbon steel,



1. "Atmosphere" Combustion Chamber.
2. Gas and Air Inlet.
3. Slot emitting curtain of gases.
4. Heating Elements.
5. Removable Vestibule Surround.
6. Refractory Lining.
7. Heat Insulation.

Showing the "Certain-Curtain" method of atmosphere control, by Birmingham Electric Furnaces, Ltd.

reheating carburised parts and similar processes requiring temperatures up to 1,000° C.

The "Certain-Curtain" atmosphere control protects the work being treated from scaling, pitting, and decarburisation to a remarkable degree. In principle the method consists in filling the furnace chamber with an atmosphere produced by the regulated combustion of coal gas and air—which may be adjusted to have either a neutral or reducing composition by means of valves used in conjunction with mixture indicators. The products of combustion enter the furnace chamber through a slot extending across the door opening, and form a screen which effectively prevents the ingress of air, thus preventing disturbance of the predetermined condition of the atmosphere and obviating undue cooling of the furnace hearth when the door is opened.

A range of Wild-Barfield "Heavy Hairpin" box-type furnaces has been introduced, and one of the standard sizes will be in operation. The salient feature of these furnaces is the patent arrangement of the heating elements, which are of heavy section nickel-chromium rod in the form of a hairpin. Other furnaces in operation include both vertical and horizontal automatic hardening furnaces. These equipments are fitted with the Wild-Barfield electromagnetic indicator, which shows when steels being hardened reach the critical point.

A wide range of heat-treatment furnaces will also be exhibited by Electric Resistance Furnace Co., Ltd., in addition to the model already mentioned. These will include "Efco" muffle furnace for general heat-treatment. The example exhibited is suitable for operation up to 1,050° C., but alternative designs are available for use up

to 1,350° C. The design is also available as a twin-chamber unit for the heat-treatment of high-speed steels. A continuous furnace for automatic heat-treatment of metal parts. A batch-charging cylindrical type furnace, with auto regulation for hardening steels. This company will also exibit a pot type furnace, obtainable in all sizes, suitable for melting low temperature alloys, such as type metal, lead, and aluminium. A similar design is also available for salt and lead baths, and for cyanide hardening of steel.

A normalising furnace of considerable merit will be shown by the Incandescent Heat Co., Ltd. It is operated on a continuous flow balanced hearth system, and is claimed to provide a solution to costly heating and heat treatment problems in the sheet and tinplate industry. In this process sheets or tinplate in special or ordinary qualities are conveyed at uniform speed through the furnace without the use of carrier or cover sheets, and are discharged flat and free from normalising buckles, without marking, scratching, or pitting of the surfaces. Heating and cooling rates being closely controlled result in a finished product satisfactory in structure, deep drawing, and manipulative qualities, and suitable for the range of specifications required in practice. It is noteworthy that when operating at a temperature up to 1,000° C. sheets may be heat-treated, either singly or in light packs, for a fuel consumption as low as 1½ cwt. per ton (depending upon the class of fuel) in a soft, reducing atmosphere with precision temperature control to within 5° C.

Piston Rings.

The importance of accurately fitting pistons is well known. They have an arduous duty to perform, but their primary function is to form a seal and maintain for a long period to ensure high efficiency. To ensure this considerable efforts have been made in designing a most suitable type and in controlling the quality of metal used. Several types by piston ring specialists will be shown at Olympia, of which mention may be made of those to be displayed by Wellworthy, Ltd., and the Clews Petersen Piston Ring and Eng. Co., Ltd. The Wellworthy heavy duty piston and scraper rings—up to and including 26 in. in diameter—are manufactured under Gray and Howlett patent process for marine and land engines, both petrol and oil. The process is claimed to ensure equalised radial pressure on the cylinder walls. These piston rings are manufactured in a number of types to reduce lubricating-oil consumption and enhance efficiency, or to prolong the life of worn cylinders without loss of efficiency. They are made from centrifugally cast, sand cast, or "pearlitic" iron, according to the requirements of the particular unit. Hardened and tempered rings for use with hardened cylinders or liners will also be a feature of this exhibit, together with the "Wellworthy Simplex" ring designed to overcome excessive oil consumption and the elimination of piston slap.

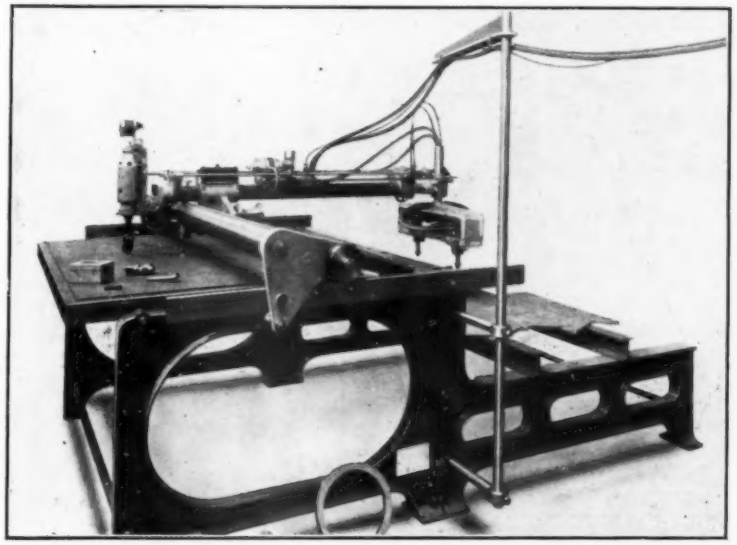
The "Clupet" patent piston ring will be exhibited by the Clews Petersen Piston Ring and Eng. Co., Ltd., while slotted scraper rings will also be shown. The Clupet ring consists of a double coil which is claimed to adjust itself automatically to the cylinder wall, and the bridge, a unique feature, prevents the escape of gas or oil past the ring. These are centrifugally cast, and they are subjected to a special process of hammering to give an outward tension.

Examples of "Aster" iron aluminium pistons, embodying cast iron waist-ring and pad pieces, designed to reduce cylinder wear, overcome piston slap, and reduce maintenance charges, will be exhibited by Automotive Products Co., Ltd.

Welding and Cutting Appliances.

Rapid development in the application of welding processes has been made since the last exhibition of this type, and improvements in equipment have kept pace with demands, there will therefore be much to attract those specially interested in these appliances. The British Oxygen Co., Ltd., for instance, are showing a selection of various types of oxygen cutting machines and demonstrations of oxy-acetylene welding and cutting equipment, different types of welding rods, fluxes, examples of welds in all usual metals, together with specimens of tested parts, will attract much attention. There will also be demonstrations of electric welding and also of metal spraying. The exhibits of this company will cover a particularly wide range, and those who are interested in the "Shorter" oxy-acetylene gear-hardening process will take the opportunity of seeing examples of its applications in various trades.

A range of oxygen-jet cutting machines and hand metal cutters will also be exhibited by Hancock and Co. (Engineers) Ltd. The machines to be exhibited include the latest Simplex universal flame cutting and profiling machine, having a cutting area of 60 in. × 40 in. in metal of any required thickness. This machine will operate



Simplex annular cutting machine by Hancock & Co. (Engineers), Ltd.

through a universal electric tracer head, having three interchangeable forms of drive—namely, direct from a drawing, direct from a template of strip aluminium, and direct from a wooden or soft metal template. This machine will also cut circles and straight lines in any direction automatically. Also a straight-cutting machine, designed for making long straight cuts of any required length, the machine being mounted on a standard 12-in. channel or joist. This machine will also cut at right-angles to the straight. It is mainly used for trimming large plates, and for cutting them to smaller sizes and into strips, the machine being capable of making several cuts simultaneously. Of special interest to shipbuilders and ship-repairers will be this firm's portable auto cutting machine, which although only recently introduced is already creating considerable interest.

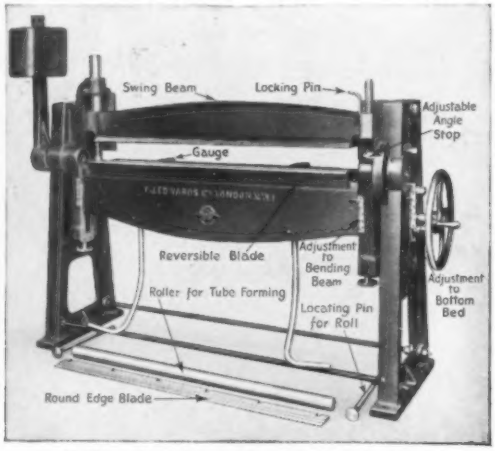
Of more than usual interest will be the display of Murex Welding Processes, Ltd. which is designed to show welding and cutting as carried out in a modern shipyard. Actual demonstrations of welding for ship construction will be given. Exhibits will include electric arc welding plant of several descriptions, also oxy-coal cutting machines. Samples of electrodes manufactured by the company will be shown. A special feature will be made of those electrodes which have obtained the approval of Lloyd's Register of Shipping—namely, Cresta, Medex, Ironex, and Fastx.

The increasing use of dies for press and stamp work has

resulted in the development of special tools particularly those that are useful for remachining press and stamp tools which have been distorted during the hardening process and for cutting from the solid irregular-shaped articles, dies, and moulds. A range of such tools is being shown by Bosch, Ltd., and also by Loranco, Ltd., which will be well worth inspection. Black and Decker, Ltd., will exhibit portable electric tools and electric grinders. These will include portable drills from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. capacity, portable sanders for sanding castings and for cleaning welding seams, grinders for fettling castings and forgings, etc.

Tinsmiths tools and accessories will be exhibited by F. J. Edwards, Ltd. These will include power and treadle guillotines of the sizes in general demand; rotary shears and universal vibrating shears of unique design, which will cut any shape inside or outside of sheets without previous piercing up to 14-gauge thick; circle cutting machines; interior cutting machines; folding and bending machines, in varied ranges from light tinsmith's folders to the heavy universal folder handling sheets up to 12-gauge thick. Particular attention should be paid to a cramp folding machine, which has recently been designed in sizes from 26 in. to $72\frac{1}{2}$ in. for either bench or stand mounting.

A range of die tools for stamp and press work, by Bosch, Ltd.



Folding, bending and box-forming machine, by F. J. Edwards, Ltd.

There will also be on view a selection of power presses, inclinable and eccentric punching presses with adjustable stroke, ranging in capacity from 4 tons to 70 tons. Hand and foot presses, and various types of swaging machines, jennies, wiring machines, grooving machines; also semi-automatic and hand-operated tin box machinery.

With the reduction in weight in highly stressed parts consisting of high tensile steels, there has been considerable concern regarding the approach of fatigue and wear, and efforts have been made from time to time to devise some form of appliance which could be used for checking the soundness of these parts. For this reason considerable attention will be paid to a new electro-magnetic crack detector, which will be demonstrated by the Equipment and Engineering Co., Ltd.

Considerable ranges of electrical and mechanical measuring, testing, indicating, and recording apparatus will be on view, such as those displayed by Elliott Bros. (London), Ltd., Short and Mason, Ltd., and Siemens Bros. and Co., Ltd. The Lea Recorder Co., Ltd., will exhibit a number of interesting specialities, including various types of their well known Lea recorders, for measuring water and sewage over weirs and in flumes, and particularly their patent compound recording and integrating machine; apparatus electrically operated to transmit readings any distance; Lea coal meters for chain grate stokers, and for mechanical stokers, in connection with Lancashire type boilers.; also the new "Romer Lea" chain operated meter for measuring coal and other materials in closed chutes. The latter will be shown in operation.

Attention should also be directed to the X-ray equipment exhibited by Philips Metalix for the examination of castings and welds specially suitable for the examination of welded boiler seams and for use in general engineering works or shipyards. Radiographs will be shown illustrating the value and importance of X-ray inspection in modern workshop practice. Of special interest is a new X-ray device for the determination of the thickness of ship's plates. This method, which renders the drilling of holes a thing of the past, is one of engaging simplicity and can be carried out by unskilled labour.

Research Departments.

One of the most interesting and informative displays will indicate some of the directions in which research carried out under the auspices of the Department of Scientific and Industrial Research is assisting British industry. Facilities for tank research and test work at the William Froude Laboratory, which is part of the National Physical Laboratory, will be illustrated by the display of a 25 ft. wax model hull, fitted with model screw and self propulsion gear, as used for tests in the new tank. Another exhibit will be a spring-plate fatigue testing machine, designed and constructed at the Laboratory, by which repeated and reversed bending stresses can be applied continuously to test plates 18 in. long, 2 in. wide, and $\frac{3}{8}$ in. thick, at frequencies of 1,000 stress applications per minute. The Fuel Research Station is exhibiting a diagram showing the results of an investigation into the cause of a number of fires in steamship bunker and cargo coal, and a series of exhibits in connection with pulverised fuel, including a new pulverised fuel short flame burner. The Chemical Research Laboratory will show a series of specimens illustrating work on corrosion and on the deterioration of structures in sea water, the latter carried out in conjunction with the Institution of Civil Engineers. The Research Council of the National Federation of Iron and Steel Manufacturers will show by an exhibit illustrating the research into blast-furnace reactions now in progress under Professor W. A. Bone, which is now reaching a stage of considerable practical importance. The factors involved in the production of coke of optimum quality will be exemplified in a group of exhibits prepared by the Midland, Northern and Scottish Coke Research Committees, an interesting feature being laboratory apparatus for determining coke combustibility. The work of other Research Committees of the Council will also be illustrated by a number of exhibits demonstrating the important part research is playing in the improvement in quality of British steel. The British Cast Iron Research Association will be represented by an exhibit illustrating recent developments in high-strength cast irons, malleable cast irons, and heat and corrosion-resisting cast irons. Modern melting equipment, including the balanced blast cupola, will also be illustrated, as well as improvements in the technique of moulding and core sand testing. The British Scientific Instrument Research Association will show a new and ingenious instrument for measuring the thickness of iron or steel plates accessible from one side only. The British Non-Ferrous Metals Research Association will illustrate researches which have led to improved materials and processes in marine and general engineering. Among these is the development of new lead alloys for cable sheathing and other purposes.

Corrosion and Cracking in Boiler Plates*

By J. W. Donaldson, D.Sc.

Developments in steam-engine practice have introduced new problems in engineering and metallurgy and have raised serious questions as to the designs and materials required to meet them. In this article the author discusses one of the problems associated with boiler plates while in service.

Stresses in Boiler Plates.

The work of the American investigators just dealt with has resulted in conclusions which, if they are not generally accepted by engineers as the solution of the problem of boiler failures, have indicated what an important part undue stresses in boiler materials can play. In fact, a certain section of engineers and metallurgists, particularly in Germany, have stated that the primary causes of failure are the stresses set up during the manufacture and assembling of boilers, and that these stresses result from want of care in the selection and treatment of boiler material and from excessive riveting pressures.

Steel used for boilers is of a low-carbon content, and is easily subjected to deformation and strain. Deformation of steel is produced as a result of cold work and by heating to certain temperatures. If steel is worked at a blue heat, 200° to 450° C., it may fracture suddenly, due to the deformation or change in structure occurring at these temperatures, and steel which has been cold-worked with deformation of the grains, and which is subjected to repeated stress at these temperatures may also fracture gradually. Steels which have been cold-worked and which are in a state of internal strain may be tested qualitatively by etching with a cuprous chloride reagent developed by Fry[8] in 1921. When this reagent is applied to mild steel which has been cold-worked and then tempered slightly at 200° C., strain lines are produced along the slip-planes of the deformed grains.

Steels which are subjected to ageing also show similar lines on etching with Fry's reagent, and such steels are also liable to crack when used as boiler material. Ageing is the term applied to mild steel originally in a tough condition, sound and satisfactory, which gradually tends to harden and become less ductile, and which on testing by means of a notched bar impact test gives a result much lower than in its original condition.

The recent researches of Köster[9] have shown that the nitrogen present in commercial steels remains in a supersaturated solid solution after slow cooling, and only separates out after prolonged heating at a low temperature. Ageing is brought about by the separation in ultramicroscopic form of nitrides from the supersaturated iron carbide solution, and this separation is accelerated by cold-working before heating, and is accompanied by a noticeable change in the magnetic properties, a decrease in the tensile strength, and an increase in the rate of solution of the steel in acids. Only steels which are subject to ageing will show strain etching with Fry's reagent, due to the deposition of the separated nitride particles along the slip lines. When Fry's reagent was first used on cold-worked steels, it was only found to be effective on certain steels, and these were principally basic-Bessemer steels. The above investigations have indicated why this should be, as the proportion of nitrogen is higher in Bessemer steel than in open-hearth steel. They have also confirmed the conclusions of Stromeyer[10] that one of the causes of brittlement in boiler-plate steel was due to the presence of nitrogen in the steel, and that the liability of a steel to brittleness depended to a large extent on its nitrogen content.

It appears, therefore, that boiler material which is deformed by cold work, or which is subject to ageing, is not only liable to become brittle, but to become brittle very rapidly when heated to certain temperatures, and to assume this condition without the influence of chemical attack. In the presence of ordinary boiler water, however, even although such water does not contain soda or sodium salts cracking is accelerated by corrosion.

Many examples of the effect of cold work on boiler-plate material have been published. Körber and Pomp[11] investigated cracking in a number of boiler parts by etching with Fry's cuprous chloride solution. They found that strain-etching developed in well-marked lines in the vicinity of the cracks, and concluded that the regions which developed these lines resulted from slip-bands due to cold work, and that such regions were more brittle, and liable to chemical attack than the remainder of the steel. More recent work by Pomp and Bardenheuer,[12] in which three cracked boiler plates were examined, attributed cracking at rivet holes to cold work producing strained material, which was further embrittled by heating at a blue heat during riveting, cracking in a flanged end plate to strained steel working under an excessive pressure, and cracking in a thick plate to the corrosion of strained material by concentration of alkaline feed water in crevices around the rivets. In each case the composition and microstructure of the steels were normal, straining being indicated by etching with Fry's reagent. The result of cold work on boiler drums has also been dealt with by Straub, Hopkins, and Whitney,[13] who have shown that cold shearing, cold bending, and even oxy-acetylene cutting are detrimental to boiler plates, and set up strained conditions which render the material more susceptible to chemical attack. Ness and MacCallum,[14] dealing with a number of cases of failure in boiler materials, also point out the detrimental effects which cold rolling, heavy caulking, and other mechanical causes have on steel.

The examples dealt with by those various investigators are supported by many others, and they all indicate the dangerous influence of cold work on boiler plates, and particularly the setting up of internal strains in the vicinity of rivet holes. It would appear, therefore, that riveting and riveting pressures must have an important part in bringing about deformation in these zones. In a series of experiments carried out in Germany some years ago to determine quantitatively the various stresses produced as a result of high riveting pressures, it was shown that in hammering a rivet head the axial pressure on the shank of the rivet caused a heavy lateral pressure against the sides of the rivet hole, that the metal in the vicinity of the rivet hole is heated, and thermal stresses are produced at a considerable distance from the hole, and these stresses are greatly increased as the riveting proceeds to a finish, and that the rivet head is pressed against the plate with considerable force, so that the annular area of the plate between the rivet heads is subjected to great pressure. It was also pointed out that the local stresses set up by these various conditions spread as far as adjacent rivet holes, so that the material at each hole is stressed at least three times. As regards thermal effects, it was found that when a steel rivet at a red heat was completely riveted a plate temperature slightly over 500° C. was attained after approximately 30 secs., so that work is therefore carried out on the plate in those local areas at a blue heat, with a very possible danger of cracking resulting, a danger which is greatly accentuated if any cold work has been previously done to

8 A. Fry, *Stahl u. Eisen*, 1921, vol. 41, p. 1093.
9 W. Köster, *Arch. fur das Eisenhuttenwesen*, 1930, vol. 3, p. 637.
10 C. E. Stromeyer, Manchester Steam Users' Assoc. Memorandum, 1922, p. 14.
* Continued from July issue, page 88.

11 F. Korber ard A. Pomp, Mitteilungen aus den Kaiser-Wilhelm-Institut fur Eisen forschung, 1926, vol 8, p. 135.
12 A. Pomp and P. Bardenheuer, Mitteilungen aus den Kaiser-Wilhelm-Institut fur Eisenforschung, 1929, vol 11, p. 165.
13 F. O. Straub, R. K. Hopkins, and H. LeRoy Whitney, *Power*, June, 1929, p. 998.
14 G. Ness and D. A. MacCallum, *Jour. West of Scotland Iron and Steel Institute*, 1927. 28, vol. 35, p. 101.

the rivet hole. In addition to high riveting pressures, severe stress may also be set up at rivet holes by the use of rivets which are tight, and by the drawing together of plates which do not exactly fit when the boiler is being assembled.

Prevention of Cracking and Corrosion.

A consideration of the various investigations and opinions expressed as to the cause of cracking and corrosion in boiler plates have led to the view that is now most generally accepted as to the cause of this type of failure. The earlier opinions expressed as to the influence of caustic soda in embrittling material have been given their proper position in the results obtained, and most authorities now attribute failure to severe local stresses in the material, accentuated by chemical attack of some form or other. If such a view is accepted, then the prevention of cracking may be brought about by a more careful selection of the materials used in boiler construction and by the careful treatment of those materials during the manufacture and assembling of boilers, together with the control of feed waters, so that dangerous concentrations of salts likely to produce corrosion are not allowed to arise.

In the selection of boiler material great care should be taken that steel for plates is in a tough, sound, and satisfactory condition, and free, as far as possible, from the presence of silicate, sulphide, and oxide inclusions, as the presence of such impurities may assist and accelerate corrosion in various ways, particularly when such impurities occur at the grain boundaries. As the presence of nitrogen in steel has been proved to be detrimental and to produce ageing, only steels manufactured by processes whereby the nitrogen can be eliminated or kept exceedingly low should be used. The use of steels of higher strength and hardness, and of greater toughness than is generally used is to be recommended. Such harder steels have a greater resistance to stresses than softer material, and owing to their higher elastic properties have a higher resistance to deformation. As the result of higher temperatures and pressures than formerly, steels having a maximum strength of 36 to 42 tons per sq. in., a minimum elastic limit of 15 tons per sq. in., and a minimum elongation of 20%, are used in marine work for boiler shells and butt straps in preference to the lower carbon steels of 27 to 32 tons per sq. in. so long employed in this class of work. Such steels, if deformed by cold work, are not so susceptible to dangerous recrystallisation on heat-treatment as steels of lower carbon content, where recrystallisation is accompanied by grain growth, the amount of which depends on the carbon content, the degree of deformation, and the temperature of recrystallisation. The advantages of using alloy steels containing 3 to 5% nickel, due to their higher strengths and yield-points, their better mechanical properties at elevated temperatures, their marked resistance to ageing, and their resistance to corrosion, have been pointed out, and where such steels have been adopted good practical results are said to be obtained from them under service conditions.

If the risk of cracking is considerably reduced by the use of stronger and harder materials, care should also be taken in the working of the material to reduce and diminish the influence of cold work. The punching of rivet holes is now seldom carried out except in the case of very soft steels, and ought to be entirely prohibited, as those are the steels most affected by cold work, and all such holes should be drilled, and where rivet holes do not fit, drifting should be avoided. Tight jointing by careful fitting, including machining, if necessary, is very essential. The cold-shearing of plates and gas cutting by means of oxy-acetylene also produce strains which are perhaps not so marked in the case of the latter process as in the former, but which have to be eliminated. The edge of plates so treated should be planned to remove the effects of the cold work, or the plates should be heat-treated at from 900° to 950° C. Any bending of boiler shells, straps, or plate ends must also be carried out at temperatures well over the critical range of the material. It is good practice to heat plates after shearing and cutting is done to 900° to 950° C., in order to remove the strains due to the cold work, and then to bend the material, while the temperature is still high, and to finish with all work before the temperature falls to the upper critical temperature.

In assembling, all cold work, such as riveting, hammering, and caulking, which will give rise to additional stresses, should be avoided. Riveting must be carried out, so that the material under the rivet head is not deformed, by adjusting riveting pressures to the quality and thickness of the steel. Proper inside caulking of all seams and rivets is advisable as preventing the penetration of corroding solutions into those areas where internal strains are possible, and where cracking takes place.

Methods or processes for the treatment of boiler-feed waters to reduce their corrosive effects depend upon the addition of alkaline salts to remove hardness and to neutralise free acids, the reduction of alkalinity where such conditions are present, the addition of substances to induce passivity or to cause the formation of protective films, and the removal of oxygen. Lime and sodium carbonate are added to boiler water containing calcium and magnesium salts, and the precipitated calcium carbonate and magnesium hydroxide removed by sedimentation or filtration. Such treatment prevents the deposition of a thick scale with bad heat-conducting properties, which may have harmful and corrosive effects on the boiler material. When sodium carbonate is used it should only be present in an amount slightly in excess of that required for softening. A large excess is dangerous, not due to the presence of sodium carbonate itself, but due to the fact that it gradually hydrolises on heating, forming sodium-hydroxide and producing caustic alkalinity which, as has been shown, may have an important influence on producing cracks.

In 1926, Parr and Straub[2] showed that a modification or control of the chemical condition of boiler water was found to be effective in preventing cracking. They suggested that where the feed water showed a high percentage of sodium carbonate the maintenance of a ratio of sodium sulphate to sodium carbonate in excess of 2 was sufficient to prevent any harmful influences. In their second paper, published in 1927,[3] these authors also stated that, as well as sodium sulphate, the presence of phosphates, tannates, chromates, and acetates, would also prevent or inhibit the corrosive action of sodium hydroxide, if these salts were present in boiler water in proper proportion, and that methods had been devised and were in operation in large power plants for the introduction of these inhibiting agents into feed water.

Evans[15] has also pointed out, in various papers, methods of water-treatment depending on the addition of substances which will produce passivity due to the formation of protective films both in acid and alkaline solutions. He has shown that great care must be exercised in their use, as such substances which reduce total corrosion may also cause serious damage by increasing corrosion at localised areas. Highly localised corrosion may also result if too little of an inhibitor is added, and be more severe than when no inhibitor is present. The importance of stresses in metals in opposing passivity by causing oxide films to crack have also been demonstrated by Evans, who has indicated that such conditions might be found in boilers and might lead to corrosion and cracking.

Finally, for the removal of oxygen from boiler water various methods are adopted. There are plants where this gas is removed by heating the water under reduced pressure. Reducing agents, such as sulphur dioxide gas and ferrous sulphate are also employed, but the more common method is to allow the water to pass over and to corrode some form of iron, thereby removing the oxygen, and numerous systems are in use in which this principle is applied in one form or another.

15 U. R. Evans, "Trans. Chem. Soc.," 1927, 1929; *Journ. Soc. Chem Indust.*, 1925, vol. 44, 163T, and 1927, vol. 46, 347T.

Thermal Expansion of Heat-resisting Iron Alloys.

Coefficients of expansion should be available for those materials extensively employed at high temperatures, and this article deals with an investigation on a series of chromium and chromium-nickel alloys with the object of determining reliable values.

CHROMIUM and chromium-nickel iron alloys are being extensively employed as materials of construction in plant used at high temperatures, and it is desirable that reliable values of expansion coefficient should be available. It is, therefore, of interest to note some new measurements, contained in a report of investigations[1] on several of the most commonly used alloys. In all, eleven alloys were investigated, and Table I. gives their chemical composition and brief particulars of their heat-treatment. It is noteworthy that apart from the carbon steel and other three specimens, the carbon content in all cases is less than 0·10% or less.

TABLE I.

CHEMICAL COMPOSITION AND HEAT-TREATMENT OF ALLOYS.

Composition.							
Cr %	Ni %	C %	Mn %	Si %	P %	S %	Initial Condition.
1·32	—	0·055	0·45	0·101	0·006	0·031	—
5·05	—	0·09	0·36	0·194	0·010	0·021	Annealed at 75° C., cooled in furnace to 650° C., air-cooled.
16·43	—	0·07	0·48	0·45	0·018	0·008	Sheet bar as received.
28·23	0·22	0·18	0·48	0·39	0·010	0·024	As hot-rolled.
17·35	8·93	0·07	—	0·45	—	—	Oil-quenched after 15 mins. at 2,000° F. (1,093° C.).
18·08	9·12	0·07	0·59	0·47	0·013	0·003	Also 0·38 Ti and 0·06 Al; annealed.
16·47	11·32	0·08	0·57	0·21	0·018	0·009	Cold-drawn (54% reduction) no ferrite.
24·50	13·28	0·18	0·39	0·23	0·010	0·010	Hot-forged.
23·50	13·25	0·15	1·92	0·49	0·012	0·011	Sheet bar.
—	—	0·28	0·03	0·06	0·01	0·01	Annealed.
18·00	8·00	0·10	Precise analysis uncertain				336 days (8074 hours) at 500° C. (940° F.) in oil-cracking unit; very slightly cold-worked in cutting specimen.

The measurements were made by the Fizeau interference method using an apparatus which enables the heating to be carried cut *in vacuo*. Details of the construction of the furnace used and also the method of calibrating the thermometers were given by Austin.[2]

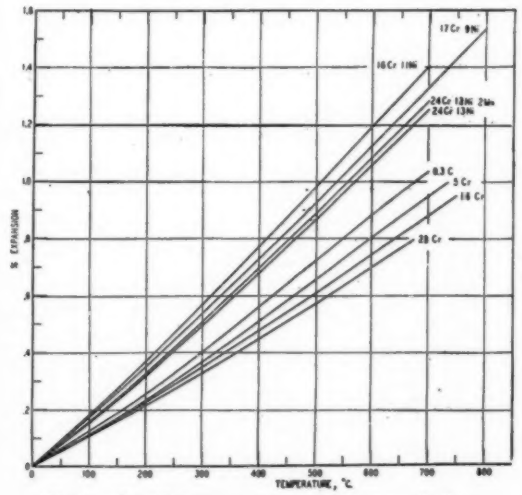


Fig. 1.—Length-temperagure curves of several alloys.

In Fig. 1 length-temperature curves are drawn which, in those cases where more than one run was made, represent the average of the several sets of observations. The length-temperature curve of the cold-worked 18–8 alloy is given in Fig. 2, where it is compared with the curve for the unworked material; this gives an idea of the magnitude and direction of the change to be expected from severe mechanical treatment of this type of austenitic alloy.

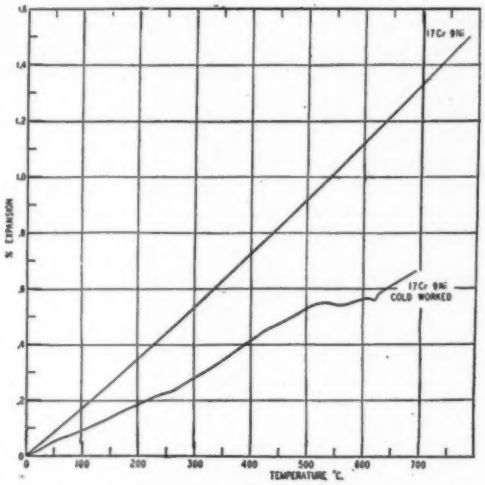


Fig. 2.—Length-temperature curves for cold-worked and unworked materials.

Some general conclusions regarding the influence of certain alloying elements on the thermal expansion of iron are drawn from the curves in Fig. 1. The addition of chromium up to approximately 20% lowers the expansion coefficient considerably; continued additions produce but little further decrease, at least up to a total of 30% chromium. The addition of nickel as well as chromium in quantities sufficient to give an austenitic structure to the quenched material increases the expansion, the exact magnitude of the increment depending on the relative amounts of chromium and nickel added. The presence of a small amount of manganese in the 25-chromium-12 nickel alloy raises the coefficient slightly, but since only one alloy containing more than the usual content of manganese was examined, there is no certain evidence that the effect is general, nor is there any indication as to the extent to which it is influenced by the chromium or nickel content. The effect of titanium in the stabilised 18–8 is slight, there being a small, though apparently real, decrease in the coefficient at the lower temperatures.

While composition is the most important factor in determining expansion, there are a few cases among those alloys which are commonly used in the austenitic condition, but which can be largely converted into ferrite by severe mechanical treatment in which the effect of extremely severe cold work must also be taken into account. This is evident from Fig. 2, which shows that by working a sample of 18–8 until it was largely ferritic (80% reduction of area through hammering, swaging, and drawing) its dilatation was reduced to almost half its value in the annealed state. The magnitude of this change is somewhat surprising, and indicates that in these alloys, just as in pure iron, the change from austenitic to ferritic structure is accompanied by a large change in the expansion coefficient. If, however, severely cold-worked metal, such as

1 J. B. Austin and R. H. H. Pierce, *Ind. and Eng. Chem.*, vol. 25, No. 7, pp. 776–9.
2 Austin, *Physics*, 3, 240 (1932).

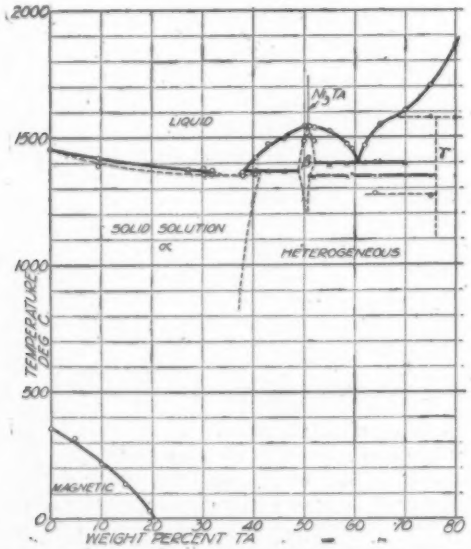
wire which has been greatly reduced in area by drawing, is to be used under conditions such that expansion is an important consideration, the coefficient of the particular alloy employed should be determined. Further work done since this paper was submitted for publication shows that 50% reduction of thickness of an 18–8 strip produces but little change in the expansion coefficient, indicating that the metal must be almost wholly converted to ferrite before the large differences described in the paper are obtained.

The effect of cold work on an austenitic alloy in which but little, if any, ferrite is formed by the treatment, is illustrated by the behaviour of the cold-drawn 18–12 sample. The first two heating runs on this specimen gave rather erratic results, the length-temperature curve showing a number of humps, presumably arising from the release of stresses. The third run gave a smooth curve, which was satisfactorily reproduced by cooling. Apart from this alloy, and the 25–12 with 2% manganese which shrank very slightly during the first heating, none of the alloys was affected, in so far as expansion coefficient is concerned, by the heat-treatment necessarily involved in the determination.

The results reported are representative of certain general types of alloys which are in common use. It is obviously impossible to cover every exact composition which may be met in practice ; not only is this unnecessary, but it is even undesirable, since it would lead to an enormous and confused mass of information. A more convenient and equally reliable system is to have certain data for representative compositions and then to isolate and to study certain disturbing factors which cause the expansion of any given specimen to deviate appreciably from that of the representative alloy. Such factors for the iron-chromium and iron-chromium-nickel alloys are now fairly well recognised, so that with the existing data on representative samples the dilation of any commercial alloys of this type can be estimated with all the accuracy needed for engineering applications.

PROPERTIES OF NICKEL-TANTALUM ALLOYS.

A STUDY of a series of nickel-tantalum alloys ranging in tantalus contents from 5 to 80% has been made by Eric Therkelsen.* The object of the study was to determine the



Constitution diagram of the nickel-tantalum system.

mechanical, chemical, and electrical properties of the malleable alloys up to 30% tantalum, to examine the microstructure, and to construct as far as possible the constitutional diagram. The metals used in the alloys were electrolytic nickel, with less than 0·5% impurities, including cobalt, and rolled tantalum sheet obtained from the Osram Lamp Works laboratories, containing less than 0·5% impurities, including columbium.

The results of the investigation shows that nickel and tantalum form a continuous series of solid solutions between 0% and about 36% tantalum, and form at least one compound, Ni_3Ta. The liquidis temperatures of the alloys between 0 and 36% tantalum lie below that of pure nickel. The compound Ni_3Ta melts at a maximum point on the liquidis. All the solid solution alloys are malleable, with strength and hardness increasing with tantalum content. An improvable alloy with about 36–37% tantalum is fundamentally possible. The thermo e.m.f. of a couple consisting of nickel and nickel-tantalum alloy (9 to 15% tantalum) is about 2 mv. per 100° C. temperature difference. The corrosion resistance of the solid solution alloys is very good, especially in the region of 12½ atomic % tantalum.

The constitution diagram constructed as far as the data taken would warrant is reproduced in the accompanying illustration.

* *Metals and Alloys*, vol. 4, No. 7. pp 105/8.

A NEW METHOD FOR DETERMINING MOLYBDENUM IN ALLOY AND PLAIN STEELS.

THE discovery of a new compound of molybdenum and the development of a new method for the rapid and accurate determination of molybdenum in steels are discussed by Dr. C. M. Johnson.[1] The latter is the result of many attempts to avoid the use of hydrogen sulphide, and therefore to eliminate the serious dangers of breathing laboratory air mixed with that gas.

If the molybdenum in acid solution be reduced by the well-known stannous chloride method and the usual red colour is developed with KCNS, on next adding cinchonine to this red-coloured solution, molybdenum quickly separates as a red to violet compound. In colour, this substance, which is a new compound, reminds one of the dimethylglyoxime precipitate from nickel solutions. This "new" composition is decolorised in NH_4OH, or caustic alkali, leaving a white flocculent precipitate.

The red colour is quite permanent, so far, in the laboratory atmosphere. The precipitate is turkey red when moist, and dries out to a handsome pale-rose shade, and is of impalpable, rouge-like texture.

Other reducing agents can be used instead of stannous chloride. For example : Reduce the iron and molybdenum with sodium thiosulphate. Then add KCNS or NH_4CNS and finally the cinchonine. By this method, the precipitate separates as a pale pink formation interspersed through a liquid cloudy with white sulphur. Colour varies from pink to red, depending on the amount of molybdenum present.

On attempting to use this compound for a gravimetric determination of molybdenum, it was found that copper is co-precipitated as in the H_2S method. It was also noted that gravimetric results, fairly close to the actual molybdenum % could be obtained in the usual run of molybdenum steels, and that neither Cr, Mn, Fe, nor V interferes. But a certain amount of tin is mechanically brought down, the removal of which causes too much lost time. It has also been found that fairly accurate and rapid quantitative determinations of molybdenum can be made with thiosulphate alone.

It was decided to try a combination method—*i.e.*, reducing with thiosulphate instead of tin salt. This scheme, it is stated, promises to eliminate H_2S from the iron and steel laboratory, providing one uses G. W. Johnson's KCNS method for copper in steel,[2] and electrolytic separations for brasses and bronzes.

1 The *Iron Age*, vol. 132, No. 2, pp. 16–17.
2 "Rapid Methods for Chemical Analysis of Special Steels," p. 587, fourth edition. Chapman and Hall, Ltd., Covent Garden, London, W.C. 2.

Oxygen in Cast Iron.

By William F. Chubb, B.Sc.

The problem of deoxidation of cast iron in regard to constitution and equilibrium conditions in iron carbon alloys is discussed; the general influence of oxygen upon physical and mechanical properties is considered, and some methods available for deoxidation are given.

RESEARCH has for many years past been devoted to the improvement of cast iron for various industrial uses by means of alloy additions such as nickel and chromium, but one cannot help feeling that the basic irons have not received as much attention as the importance of their development would seem to deserve. Indeed, although the literature published in the various technical journals has been devoted to many outstanding matters of interest such as desulphurisation, heat-treatment, superheating, and alloying of cast irons, that of deoxidation does not appear to have received the full consideration that is warranted by so important a subject. The research results already reported on this subject are very widely distributed throughout the journals and the correlation of data relating to it is a task of some lengthy duration. In writing, therefore, on this problem of deoxidation of cast iron the author's hope has been to present only those results which seem most to advance our knowledge, while at the same time co-ordinating them with his own observations of cupola-melted irons.

It is necessary to consider this problem from three viewpoints—namely, in regard to constitution and equilibrium conditions in iron-carbon alloys, then to pass to considerations of the general influence of oxygen upon physical and mechanical properties, and finally to discuss in some detail the methods available for deoxidation.

Constitution of Oxygen-bearing Cast Irons.

In considering this aspect of the question, one is forced to admit straight away that the problem is not a simple or straightforward one, for the reason that research on the iron-carbon-oxygen system has so far been confined very largely to the left-hand side limits of the equilibrium diagram, or, in other words, to those alloys of low carbon content. Indeed, consideration of researches upon which these equilibrium diagrams have been drawn up clearly reveals that the possible presence of oxygen has in many instances been completely ignored. For example, much of the work has been developed using Armco iron as the basic material for the preparation of carbon-bearing alloys and analyses of this material invariably indicate the presence of oxygen in ponderable amounts, usually of the order of 0·03% to 0·06%. Even vacuum-melted iron electrolytically produced cannot be with safety regarded as free from this gaseous impurity. For this reason, quite apart from others arising from the presence of both metallic and non-metallic impurities, it is clear that our present knowledge of equilibrium conditions is by no means accurate, and must rather be considered as representing those of ternary, quaternary, or of even more complex alloys of iron-carbon and oxygen combinations. Further, it cannot be claimed that the alloys used in the preparation of any one equilibrium diagram so far advanced have been of uniform oxygen content. Were this possible, exterpolation or modification to determine the true equilibrium conditions might be a matter of considerably less difficulty, once the known general influence of oxygen were established. With these thoughts foremost in their minds, many research workers have even doubted within recent years the existence of certain thermal transformation temperatures in the purest irons so far examined. The present author, however, having regard to all the evidence presented, considers that this is an over-statement of the case, but the fact that doubts of such a serious nature and importance have arisen suggests that the whole question is by no means clearly defined. In this then lies the difficulty of discussing the iron-carbon alloys from considerations of the equilibrium diagram. How much more difficult, therefore, must be that of the higher carbon alloys which constitute the cast iron series?

To appreciate these difficulties more fully it is perhaps necessary to recall the work of many research workers upon the solubility of oxygen in iron. It has been shown that liquid iron can dissolve oxygen up to 0·21%, and that its maximum solubility in solid α-iron is 0·05%. For γ-iron it is stated to be somewhat higher. These figures have received confirmation from various sources, notably from the work of Schonert (Zeit. fur anorg. Chem., 1926, Vol. 154, pp. 220-225), who has further indicated that at maximum solubility the fusion point is depressed to 1,509° C. With a higher oxygen content two solid phases make their appearance, and these consist of ferrous oxide with small amounts of ferric oxide and 0·99% of free iron. The same author has also published (loc. cit.) an interesting departure from the equilibrium diagram of Tritton and Hanson, but it is not within the purview of this article to discuss the many questions of controversy which arise from it. Enough has been said, however, to indicate the many doubts which must arise concerning our conception of iron-carbon-oxygen equilibrium conditions. Quite apart from this influence, the presence of oxygen in alloys of low carbon content has been held by many authorities as responsible for certain age-hardening phenomena reported to occur after quenching from below the A_1 transformation, and this serves to show the importance of the whole question of oxygen content to the engineer and foundryman.

Now it is very improbable that in cast iron oxygen can exist in elemental condition, especially in presence of the high silicon contents, and considered metallurgical opinion leans to the belief that it can exert no direct influence and to the belief also that should oxides of carbon, or, indeed, other oxides such as those of iron and manganese be present, the influence felt is rather that of the particular gas occluded or of the metallic oxide present. Yet more than one experienced observer has reported the presence of oxygen in gases extracted from vacuum-melted samples. At the same time, the evidence which may be collected does not point definitely to the existence of free oxygen in the molten metal, and the problem then resolves itself into one of determining the effects of carbon oxides found invariably in pig irons from the blast-furnaces, as well as in gases abstracted from molten cast irons.

In reviewing this aspect of the problem, one finds very few, if any, references to the relations of carbon oxides to the equilibrium diagram, so that the influences exerted by these gases on the solid metal cannot be discussed or foretold from this standpoint. For our knowledge we are then forced to rely upon observations from test specimens cast under known and controlled conditions, and it will at once be apparent that the amount of these gases present must vary considerably with casting conditions. Of these conditious, that of casting temperature is probably the most important, and in this connection the published work of Hailstone (Carnegie Memoirs, J.I.S.I., 1916) is of great interest in showing that at

low casting temperatures of about 1,250° C. not only is the proportion of carbon dioxide greater than that produced in irons poured at considerably higher temperatures of over 1,400° C., but that this increase in carbon-dioxide evolution is obtained at the expense of carbon monoxide. At the same time, however, the total amount of gas evolved, consisting of admixtures of these two gases with nitrogen and hydrogen, is progressively increased as the casting temperature is raised.

The foundryman's chief interest in these questions lies, naturally, not so much in any academic discussion of research results, but rather in the influence which dissolved gas must exert during the production of castings. Here it must be observed that the problem is mainly that of preventing the formation of blowholes and porosity. These result from the known change in solubility of gases during freezing, for the solubility is much lower in the solid state. However, evolution of gas may, of course, arise from other and totally different sources, such as the possible reaction between metallic oxides and carbon. Hence, the need for the use of deoxiders and degasifiers is at once recognizable.

The direct influence of oxygen-bearing gases is not, of course, readily apparent, but this indirect influence in the production of unsoundness is one of first importance to engineering. For this reason it is proposed to consider the influences of oxygen-bearing constituents as a means of indicating in what directions improvement will be likely to result from various treatments designed to remove gases, either partially or totally.

(*To be continued*).

Developments at the Butterley Iron Works

The long established works are keenly alive to the need of maintaining a progressive policy, and this article describes recent developments of an old established iron works.

THE Butterley Iron Works was among the first engineering concerns to be established in this country, and dates back to 1790, when the company was first formed. Since that date a progressive policy has been steadfastly pursued, until at the present day the works comprise large constructional shops, machine shops and foundries, where a very comprehensive range of work is undertaken, including colliery equipment, structural steelwork, castings up to 20 tons in weight, special acid-resisting castings for chemical works, and general engineering work of every class.

Recently further extensions have been carried out, which include a new sub-station containing three rotary converters and transformers, together with starting panels and high- and low-tension switchboards. The whole of this equipment was supplied by the General Electric Co., Ltd., and was manufactured at their engineering and switchgear works at Witton, near Birmingham.

Power is supplied to the sub-station at 6,600 volts, 3-phase, 50 cycles, and is converted to 250 volts D.C. by one 150-kw. and two 300-kw. rotary converters, which feed a two-wire system. A separate transformer of the oil-immersed, self-cooled type is installed for each rotary, and steps down the initial voltage of 6,600 to 182 volts. The rotaries are arranged for starting by means of pony motors, the starting panels being of the self-synchronising type. This type of starting panel ensures that when the machine has run up to its synchronous speed its polarity is always correct. Each panel is equipped with an indicator lamp and a seven-way switch, by means of which earth leakage on the low-voltage side of the transformers can be readily detected.

The high-tension switchgear consists of a five-panel truck cubicle switchboard, one panel controlling the incoming supply, three panels controlling the high-voltage side of the rotary converter transformers, and the remaining panel controlling the supply to a 210 kv.a. power transformer. Each panel is equipped with a hand-operated oil circuit breaker of 50,000 kv.a. rupturing capacity, the breakers being provided with overload and no-volt releases. The rotary converter panels are provided with ammeters and wattmeters, while the incoming supply panel is equipped with an ammeter, power factor meter, watt-hour meter, and recording frequency and voltmeters.

A fifteen-panel flat back switchboard controls the low-tension supply, and is built up of polished slate panels with bevelled edges, the panels being mounted on angle-iron framework. Of the fifteen panels, three control the D.C. supply from the rotary converters, six 600-ampere feeder panels supply power to various parts of the works, three are connected to 50-ampere feeders for the offices and employees' houses, while two have been left blank for future extensions. A B.O.T. panel is also included to provide earth leakage indications.

Each of the rotary converter panels is equipped with two hand-operated single-pole circuit breakers of the line-contact type, which are provided with overload relays and reverse current, and no-volt trips. These breakers are arranged for independent closing and simultaneous tripping. The breakers controlling the 300-kw. rotaries are rated at 1,800 amperes, while those for the 150-kw. set are of 800 amperes capacity. A shunt regulator, ammeter, and watt-hour meter are mounted on each panel.

The feeder panels are similar to those already described, except that no shunt regulators are required, while the breakers are designed for 600 and 50 amperes, and are provided with overload protection only. The voltage of the supply from the rotary converters and the busbar voltage are given by two sector type instruments, which are mounted on a swinging bracket at one end of the switchboard.

We are indebted to Mr. S. I. Smedley, manager of the Butterley Iron Works, Derby, for permission to publish this description.

Chrome-Molybdenum Castings for Oil Industry.

ACCORDING to the *Iron Age*,* a low-chromium casting steel alloyed with 0·50% molybdenum has been added to its list of cast alloy products by the Lebanon Steel Foundry, Lebanon, Pa., to meet the requirements of oil-still parts. High strength and resistance to corrosion, especially to that of hydrogen-sulphide gas at high temperatures, and also a small creep factor are among the special specifications that should be satisfied; and headings, fittings, and impellers made of the alloy have undergone the test of service.

The chromium content ranges from 4·5 to 6·5%, and the carbon from 0·15 to 0·35%. The tensile strength is guaranteed at nearly 50 tons per sq. in., with a maximum expected value of about 55 tons. The corresponding yield-points are 33 and 40 tons; the elongation is 16%, guaranteed with an expectation of 20%; reduction in area, 30 and 55%, and the Brinell hardness 215 to 255. At 1,000° F. the yield-point is nearly 27 tons per sq. in., and the tensile strength about 33 tons.

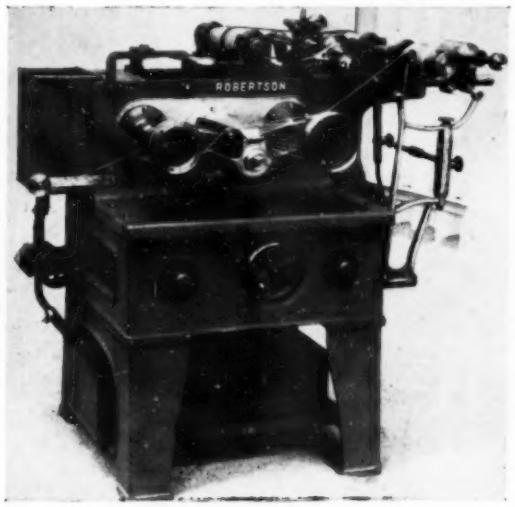
* Vol. 132, No. 5, p. 15.

Recent Developments in Tools and Equipment

A NEW HIGH-SPEED WIRE DRAWING MACHINE

THE number of machines developed in this country for drawing fine wires are all too few, thus when a British machine for this class of work is devised particulars regarding it are of interest. This is especially true of a "Richards" patent high-speed wire drawing machine which has just been developed for drawing ferrous and non-ferrous metals to any dimensions between 30 s.w.g. and 50 s.w.g. on spools from $1\frac{1}{8}$ in. to 4 in. core diameter and from $1\frac{1}{2}$ in. to $4\frac{1}{2}$ in. traverse. Built by W. H. A. Robertson and Co., Ltd., of Bedford, the machine has several features which cannot fail to commend themselves to the practical wire-drawer.

It is designed to give a drawing speed up to 5,000 ft. per min., as required, and by means of a variable speed ratio of 50% spooling speeds of 2,000 ft. to 4,000 ft. per min. are obtainable at will, and whilst the machine is running. It will draw wire up to the maximum speed the dies will stand, and has been developed from experience gained with fine wire drawing machines of all types. It is claimed that no other machine embodies so many features which the operator requires.

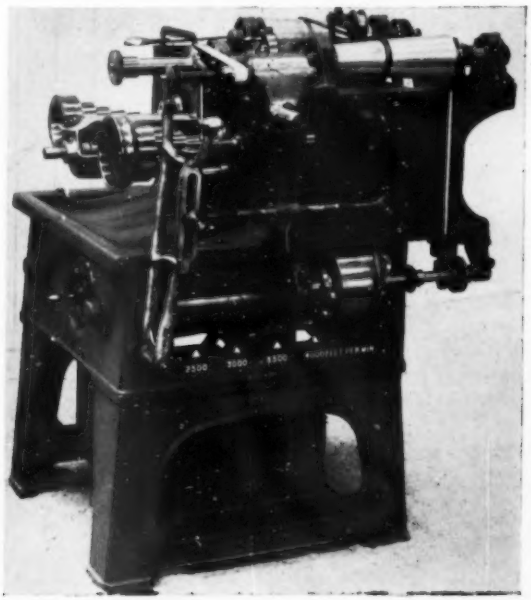


The figure "8" system of stringing up.

In addition to the variation of spooling speeds while the machine is running, an easily operated starting gear facilitates the threading of the dies. An important feature is the patent figure "8" system of stringing up, which utilises all the cones for drawing purposes, and there are thus no idlers. The machine which is shown in the accompanying illustrations is very easy to thread up, and allows a cone step width which is double the amount usually provided. The wire is traversed across the cones to prevent cutting-in, and the value of the greater surface in reducing wear of the cones is a useful advantage.

The stringing-up system employed enables the use of a special die-box and die-holders which have several advantages: thus, for instance, each die can be adjusted separately in any plane and set definitely at right-angles to the wire. This has a marked influence in reducing the amount of wear on the dies and their tendency to wear out of round. The arrangement prevents the possibility of the wire coming into contact with anything but the die on its passage from one cone to another; further, the pull on the die-box is almost balanced in each direction, giving a longer life to the die-traversing mechanism, and preventing vibration of the die-box. Special attention has been directed towards the provision of efficient lubrication, and in this machine the lubricant is carried to the die by means of a small fountain in front of the die through which the wire passes. In this way the wire is clear from accumulations in the tray, since the lubricant is pumped from a tank beneath the machine, through two filter screens to the header tank, and hence only clean lubricant is supplied to the outlets immediately under each die.

The patent automatic spooling gear is of particular interest. It is so arranged that it definitely controls the speed of the spool as each layer of wire is added. The adjustment of speed per layer can be varied by very small amounts, and can be correctly reset to suit any size of wire by adjusting to a divided scale. Stretch in the spooling drive is automatically taken up with a spring-loaded jockey pulley and it is noteworthy that the lay of the wire on the spool remains constant throughout the spool, whatever number of layers be added. The machine accommodates spools with an inside to outside diameter ratio up to 2 to 1. In addition, the width of traverse can be instantly adjusted within fine limits, whilst the machine is running and can be varied from $4\frac{3}{4}$ in. to $1\frac{1}{4}$ in. to suit various spools. Further, the wire on the drawing cones is traversed slowly across the face of the cone, and its zone of contact can be varied while the machine is running, while a special take-off pulley is provided to give additional pull for soft drawing of the larger diameter wires. For spooling special wires, the tension can be adjusted by hand and the automatic gear cut out, a method that is sometimes preferable on expensive wires, where the labour cost is of secondary importance.



The automatic spooling mechanism.

The machine is designed to suit dies with a constant elongation per die, and thus cones with a proper percentage of elongation can be provided to suit the particular materials to be drawn, as obviously high speeds cannot be attained

unless the elongations per die and the cone steps properly correspond and are correct for the material to be drawn. The figure "8" method of stringing up, and the special design of the die-holders, enables the machine to accommodate cones with varying elongations without difficulty. The lubricating system adopted enables the dies to remain cool, even when wire is drawn at the highest speeds for

A plain view showing the special die box in relation to the cones.

long periods. In some designs the finishing die, which is relied upon to finish the wire dead to gauge and free from scratches, is frequently mounted close to the spool and lubricated with a sponge or wet rag; in this machine, however, the finishing die, together with the other dies, receives correct lubrication and consistent production of highly finished wire results.

BOILER DRUMS FOR NEW POWER STATIONS AT FULHAM

SOME time ago we announced the success of the English Steel Corporation, Ltd., in being awarded the contract for 18 boiler drums for the new power station at Fulham. These drums are amongst the largest of this type to be

Forged boiler drum for power station at Fulham.

made in this country, and by the courtesy of the Corporation we are permitted to show in the accompanying illustration one of the rear drums forming part of this order. This drum has an internal diameter of 54 in., is 40 ft. 9½ in. long, and weighs 52 tons. It is of interest to note that the drum has been forged in one piece with integral ends closed by a special process developed by the English Steel Corporation. It will be noted that both ends of the drum are closed or "bottled," in which case it is usual to defer the closing operation; a tube with open ends being produced first and subsequently bored to size. The exterior is also partly machined at this stage, sufficient excess of material being left on the ends to ensure the success of the closing operation. In the closing process each end of the open-ended tube is placed between specially shaped swages, under a hydraulic press. These tools are pressed together slightly, reducing the diameter of the tube by the amount the press head has travelled, but increasing the size in the reverse direction. The tube is rotated, and the process repeated as quickly as possible. In this way the forging is ultimately reduced to the dimensions required, whilst the wall is thickened in the process. Slight modifications in the method are necessary, according to the particular shape of the ends, but in principle the process is similar.

The large size of the forgings required is sufficient in itself to make the production of such vessels a matter of note from an engineering point of view. Their manufacture calls for plant and experience which few firms possess; the English Steel Corporation has, however, ample resources for this type of work. It is noteworthy that, in addition to the order for Fulham power station, this firm is manufacturing boiler drums for the new power stations at Brighton and Swansea.

BRITISH STANDARD FILES AND RASPS

A SHORT while ago the File Manufacturers' Association issued an agreed list of files in which a large measure of simplification in the number had been achieved. In order to secure as much support as possible for the adoption of the new sizes, the manufacturers approached the British Standards Institution with a view to the new sizes being incorporated in a B.S. Specification, and a specification which has just been published has accordingly been based on the proposals of the manufacturers.

Whereas originally there were some thousands of different sizes and types of files, the Standard Specification provides for only 234 standard files of 24 different types, and the views of industry indicate that these are sufficient to meet the normal demands of engineering. The specification is in two parts. The first part is devoted to nomenclature, and a description, together with an illustration, is given for each different type of file. The second part of the specification includes 29 tables giving the overall dimensions and the number of cuts for the various types. Tolerances on both the dimensions and number of cuts are laid down in the specification.

In the course of the discussions of the drafting committee stress was repeatedly laid on the need for a standard method of file testing, and the File Manufacturers' Association have consequently given this matter their closest attention. A very thorough investigation is, at present, being carried out at Sheffield University under Professor Lea, and considerable progress in arriving at a satisfactory method of test has already been made. It is hoped that in the near future the result of this work will form the basis for a further B.S. Specification, dealing specifically with a standard method of testing files.

Copies of this Specification (No. 498–1933) may he obtained from the Publications Department, B.S.I., 28, Victoria Street, London, S.W.1, price 2s. 2d. post free.

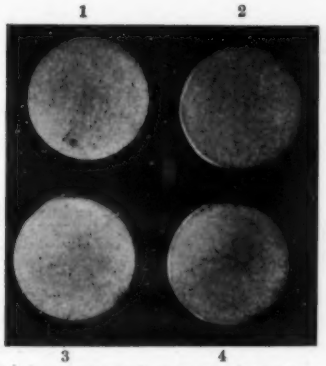
The qualities of aluminium employed in the various branches of the gas industry are used not so much because of lightness, but because aluminium is immune from chemical attack by the majority of the products of coal distillation, by the majority of the products of gas manufacture, and by the products of combination of gas itself. All interested in the gas industry should see the interesting booklet entitled, "Aluminium in the Gas Industry," recently issued by The British Aluminium Company Limited, Adelaide House, London, E.C. 4.

Prevention of Grain Growth in Wrought Aluminium Alloys

By D. R. Tullis

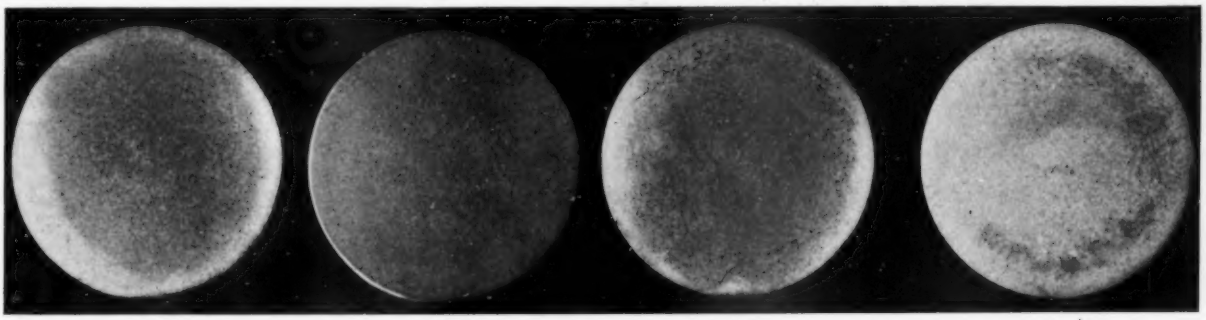
(Chief Metallurgist and Director of Cindal Metals, Ltd.)

Many processes are claimed to repair aluminium alloys in an effort to overcome grain growth phenomena. In this article some of these processes are discussed in relation to wrought alloys.



Treatment of specimens as in 1¼ in. diam. extruded bars.

Cross-sections from ⅝ in. diameter extruded bars in aluminium-zinc alloy. Specimens polished and etched.



1 As extruded.

2 Soaked 500°C. for 6 hours and quenched cold water.

3 Soaked 530°C. for 1 hour and quenched cold water.

4 Soaked 500°C. for 24 hours and quenched cold water.

Cross-sections from 1¼ in. diameter extruded bars in aluminium-zinc alloy. Specimens polished and etched.

ALUMINIUM and most of its alloys will, when subjected to prolonged heating at or near its critical temperature, exhibit the phenomena of grain growth. The extent of the grain or crystal growth will depend upon a number of factors, and for a given set of conditions will vary from one batch of metal to the next, although in all respects the analysis may be the same.

The conditions of grain growth may be divided into two main groups—(*a*) physical conditions; (*b*) chemical conditions. In the first group it is necessary to consider temperature, stress or amount of plastic deformation, time, casting conditions of the piece—*e.g.*, chill or sand cast, or from extruded bar. In the second group chemical analysis is the main factor, also amount of other metals present, and type of other elements and presence of grain growth inhibitors.

In the case of pure aluminium, and also most of its alloys, the conditions which bring about most marked grain growth are those which approach closely to the conditions necessary to bring about single crystal formation in stressed and heated bars. From the work of Carpenter and Elam on aluminium[1] and aluminium-zinc[2] alloy single crystals, the conditions most satisfactory to bring about single crystal formation in aluminium are brought about by heating to 550° C. for 6 hours, then subjecting to a stress of 2·4 tons per sq. in., followed by heating to 450° C. and gradually increasing the temperature to 550° at the rate of 25° C. per day. The total time required is therefore 100 hours.

It will be seen, therefore, that the above temperatures approach rather closely to the condition known as soaking at forging temperature, 450° to 500° C.

In producing forgings and stampings in light aluminium alloys, it is extremely difficult to prevent grain growth unless special treatment is applied to the metal before fabrication into forgings, etc.

The conditions of forging often closely approach the correct conditions necessary to produce single crystals in some parts of the forging. This results in the production of very large grains, which occur in some parts of the forging, and are more accentuated during subsequent heat-treatment. Early failure in service due to fatigue and intercrystalline fracture, can in nearly all cases be found to have occurred in the areas which have exhibited the grain growth phenomena.

For some reason not fully explained, the grain growth phenomena is much more liable to occur in forgings which have been produced from extruded bars or sections. In fact, extruded bars themselves when subjected to suitable heat-treatment, are prone to develop excessive grain growth. It is now a well-established fact that the addition of certain elements to light aluminium alloys will retard the grain growth phenomena in forgings, etc., and also prevent the formation of excessively large grain structure in the cast billet. The use of Titanium in the R.R. type of alloys is intended to prevent as much as possible the formation of excessively coarse grains in the cast material.

Titanium, however, will not prevent the formation of columnar crystals in chill-cast billets, and in subsequent forging and heat-treatment it will not prevent the grain growth phenomena. The only element known at present which will entirely prevent both phenomena is atomic boron, which is introduced into the molten alloy by the well-known B.C.L. process.[3] This represents a very important discovery in the improvement of light aluminium alloy forgings. The effectiveness of the result, however, depends on the amount of treatment given to the metal prior to casting and subsequent forging. It is not possible

1 "Proc. Royal Society, 1921," 100A, 348.
2 16th May Lecture, Institute of Metals, 1926.

3 "Proc. of Institute of British Foundrymen," vol. xxiii., 1929-1930; also vol. xxiv, 1930-1931.

to state at present whether all forging type aluminium alloys can be rendered immune to grain growth by application of the process.

It has also been found that metal which has been treated by this process and intended for the production of chill castings free from columnar crystals, and also resistant to grain growth on subsequent heat-treatment, will necessarily resist the combined effects of plastic deformation and heat-treatment without exhibiting the grain growth phenomena.

In order to render the metal entirely immune from any of these defects, it is necessary to prolong the initial B.C.L. treatment, and at the same time it may be necessary to slightly alter the composition of the alloy.

As an example, a number of tests have been carried out on an aluminium-zinc alloy, containing approximately 14% of zinc, and treated by the B.C.L. process. This alloy was cast in the form of 5-in. diameter chill-cast billets. A cross-section of the billet after polishing and etching showed that it was entirely free from columnar crystals.

The billets were extruded into $1\frac{3}{4}$ in. and $\frac{5}{8}$ in. diameter bars. Specimens were cut off these bars and subjected to various heat-treatments calculated to bring about grain growth. In none of the examples shown did the grain growth phenomena take place.

PURE ALUMINIUM.

Strength of small crystal test-piece, 4·5 to 4·7 tons per sq. in.

Strength of single crystal test-piece, 2·8 to 4·08 tons per sq. in.

Fracture always takes place across one of the crystals, but never at the boundary.

For single crystal formation in 18·5% zinc-alloy, the load is 12·2 tons per sq. in.

INTERNATIONAL ORGANISATION OF CHEMISTRY RECORDS.

RESEARCHES and investigations are progressing at such a rapid rate that questions regarding the maintenance of proper records of work done have assumed increasing importance during recent years.

A step in this direction has been taken in the field of chemistry by the institution of the International Office of Chemistry. This was created at the international convention in 1932, and its headquarters are in Paris. Since the institution of this Office a strong committee has been formed which includes: Messrs. F. Donker Duyvis, Member of the Council of Patents, The Hague; P. Dutoit, Professor at the University of Lausanne; F. Haber, Director of the Kaiser-Wilhelm Institut für Physikalische Chemie und Electrochemie, Berlin; E. Hauser, Member of the Academy of Sciences, Madrid; Ch. Marie, Secretary-General of the Comité International des Tables Annuelles de Constantes, Paris; N. Parravano Member of the Academy of Italy, President of the Comitato Nazionale di Chimica, Rome; G. Peny, President of the Federation of Chemical Industries of Belgium, at Brussels; J. C. Philip, Professor at the Imperial College of Science and Technology, London.

After careful consideration of the problems associated with the maintenance of scientific and technical records this Committee has formulated recommendations determining the functions of the Office. These are briefly summarised under three principal heads, viz.:—

1. To render accessible to all interested persons existing records accumulated in various centres, depots, and collections.

2. To control and give guidance to the preparation of new records, in such a way as will facilitate registering, filing, and diffusion; adopting methods which experience indicates to be the best.

3. To ensure co-ordination between the records relative to chemistry, and that concerning other scientific information in the field of international records.

The establishment of this Office, together with a practical and rational method of acquiring from all over the world the requisite information in chemistry, for recording purposes, will undoubtedly be of greater value. In this instance we understand this is being carried out systematically and progressively, and in such a way as to be more and more effectively adapted to the needs of the users of such records.

Distribution of Phosphorus between Iron and Iron Phosphate Slags containing Lime.

IN the April issue of Archiv für das Eisenhüttenwesen, W. Bischof and E. Maurer present data on the equilibrium between molten iron and slags consisting of ferrous oxide, phosphoric anhydride, and lime. With slags containing ferrous oxide and phosphoric anhydride only and irons containing phosphorus up to 4% by weight, the distribution of phosphorus between the iron and slag can be best expressed by the ratio $(P_2O_5) : P$, where (P_2O_5) means the concentration of phosphoric anhydride in the slag and P that of phosphorus in the iron. This ratio is equal to 5·8 when the concentrations are given in per cent. by weight, and equal to 1·8 when expressed in molar percentages. The course of the $(P_2O_5)/P$ curve at higher concentrations indicates that ferrous phosphate, $3FeO \cdot P_2O_5$, is present in the liquid slag. In the case of slags without lime the effect of temperature upon the distribution ratio is only small. When lime is added the ratio greatly increases with increasing lime content showing a maximum value at 40% by weight of lime. On the other hand, with rising temperature the ratio rapidly decreases.

SOME RECENT INVENTIONS.

(*Continued from page* 114.)

temperature of deposit of which are different. The process is particularly applicable to joining railroad and tramway rails or other steel parts by casting metal between them, molten steel at a temperature of 1,500° C., and containing, in addition to the usual 0·8% of carbon, one or more of the following metals up to the percentage stated: nickel, 5; chromium, 2·5; tungsten, 1·5; molybdenum, 1; and copper, 3, is used, and the joint is heat-treated *in situ* in order to restore the physical properties of the metal which has been melted or superheated. The parts to be joined may be preheated to 650°–1,200° C.

For ordinary rails containing carbon, 0·2–0·6%, and manganese over 0·6%, steel containing the following percentages is used: carbon, 0·1–0·4; manganese, silicon, and copper up to 1; nickel, 0·2–3; chromium, 0·8; and molybdenum and tungsten up to 0·5, and the joint is afterwards heated 900–1,000° C. for 30 mins. When very hard steel is to be joined—for instance, that containing 0·6% or more of carbon and of silicon—the molten metal contains the following percentages: carbon, 0·1–0·6%; manganese, molybdenum, tungsten, and silicon up to 1; nickel, 0·2–5; chromium up to 2·5; copper up to 3, and the joint is heated to 1,000° C. for 30 mins., and then to 850°–950° C. for 30 mins.

When joining rails having a fine grain through water-quenching, and containing 0·2% of carbon and 0·4% of manganese, the molten metal contains the following percentages: carbon, 0·1–0·4; manganese, silicon, and copper up to 1; nickel, 0·2–3; chromium, 0·8; and molybdenum and tungsten up to 0·5, and the joint is heated to 1,000° C. for 30 mins., quenched in water or an air emulsion thereof, and then heated to the higher transformation point to temper or merely cooled by the water to 800°–900° C. By thus adjusting the composition of the cast metal and the heat-treatment, it is stated all the zones of the joint have similar properties as regards strength, etc.

387,865. C. L. DELACHAUX, Gennevilliers, France. February 16, 1933.

Business Notes and News

New Type of Coal-Washing Plant Installed

A type of coal-washing plant which is new to this country has recently been installed at Messrs. J. and J. Charlesworths' Newmarket Colliery. This installation is worked on the sand-flotation system. Separation is carried out in the new plant entirely by gravity, so that variations in the size and shape of the particles, the shale in the raw coal, or in the rate of feed, do not affect the washing efficiency. The operating density can be altered in a few minutes for washing different seams. By enabling a sharp cut to be made at the required density the process results in a clean coal of a minimum ash with the maximum yield.

A cone separator is used to contain the sand and water. The raw material, from which the dust has been removed, is fed through a chute on to the top of the fluid mass. The agitation water is introduced through rings at the sides of the cone, and also to the classifier column at the base of the cone.

The hydraulic agitation is assisted by a mechanical agitator. The first section of this screen removes the sand and water, and the remainder of the screen sizes the clean coal for delivery to railway wagons.

The sand and water, after passing through the screen, are collected and returned to a main sand sump, which separates them for pumping back to the cone, and so maintains the level of the fluid mass.

The construction of the plant has been carried out by Messrs. Fraser and Chalmers, of Erith, Kent.

Welding in Shipyards

Considerable controversy is being waged in shipyards regarding the formation of a new body of skilled workers for welding operations. No one doubts the need for skilled operators, but boiler-makers are claiming a monopoly. Actually, the rapid developments in the application of welding processes are displacing men in several other shipyard trades, and these trades, as well as the employers, strongly object to the claim of the boiler-makers. The employers propose the creation of a new class of shipyard workers, to be called ship-welders, and suggest that suitable men should be given a course of training. It is proposed that the sort of labour from which the new class is drawn should be riveters, caulkers, drillers, angle smiths, ordinary smiths, and fitters, while in certain cases patterns will not be required, which should make pattern-makers eligible. A meeting was held at Edinburgh recently in an effort to come to an amicable decision, but, at the time of writing, without success. There is room for mutual toleration in this question, and doubtless it will be forth-coming.

Presentation to Mr. W. R. Lysaght.

An interesting ceremony took place recently at the annual works gala of the Normanby Park Steelworks, Scunthorpe, when Mr. W. J. Lysaght, managing director and founder, was presented with an illuminated address in celebration of the twenty-first anniversary of the commencement of operations at these works. Mr. J. Owen, chairman of the Joint Works Committee, made the presentation, and paid a tribute to the recipient, and stated that the employees desired to place on record the kindly consideration he had always shown for their welfare. In supplementing the expressions of good feeling which existed in the works, Mr. W. J. Brooke, general manager, said it was twenty-one years ago since their first furnace had gone into blast, and since then the works had experienced many vicissitudes. There had been many times when they hardly knew whether the works would keep going or not, but to-day they were able to say that they probably had a larger share of the iron and steel trade of the world than any other steel-works, and certainly in Great Britain.

Mr. Lysaght, in expressing his thanks, said he always looked upon the Scunthorpe Works as a model plant, and it was certainly one of the best balanced in the country. During the last few years thousands of tons of steel formerly bought abroad was now obtained from Scunthorpe for their other works at Newport and Bristol, and they had consistently paid a good deal more for steel from Scunthorpe to keep the works going. Every ounce of steel used in their other works came from the Normanby Park Works, and he saw no reason why they should not continue to have good trade.

Steel Companies' Merger

In our last issue we referred to the proposed merger of the South Durham Steel and Iron Co., Ltd., with Dorman, Long and Co. Separate meetings were held by an order of the High Court of holders of the 4½% Perpetual Debenture stock, of the 6% Cumulative Preference shares, of the £1 Ordinary shares, and of the £1 "B" Ordinary shares. At each meeting the scheme came in for adverse comment.

Voting in every instance—on a resolution approving and agreeing to the scheme—was by card. Since the meetings, Sir William Henry Peat, the chairman, of Messrs. Peat, Marwick, Mitchell and Co., chartered accountants, states that the resolutions adopting the scheme of arrangement for the merger of the South Durham Steel and Iron Co., Ltd., with Dorman, Long and Co., were, in his view, duly carried by the requisite statutory majorities of the respective class meetings of the South Durham Steel and Iron Co., and that he is reporting to the Court accordingly.

World Tin Survey

The International Tin Research and Development Council announce that steps have been taken in the preparation of an exhaustive world market survey. Col. S. Heckstall-Smith, director of development of the Council, has recently completed a tour of the most important European countries, and extensive reports are being prepared in the countries visited. Particular attention is being paid to developments in the electrical engineering and automobile industries, and the possibilities of further mechanisation of agriculture are being closely studied. Canning is regarded as one of the most important industries, capable of great expansion, but many problems have to be faced in its development.

There appears to be the nucleus of large and prosperous canning industries in Germany, Italy, Belgium, and Holland, and it is anticipated that the educational campaign undertaken by the Council will do much to popularise internationally, and stimulate, the canning of local delicacies in the various centres of production. The results of this survey will be published in due course, and should give a clear picture of potential markets to British producers and exporters in the tin-consuming industries.

Shipping Dividends Reflect the Times

Possessing the largest and probably the most efficient mercantile marine in the world, the British shipping trade is more vulnerable and open to attack both by foreign competitors and by political and economic events than it otherwise would be. This opinion was expressed by Lord Essendon, chairman of Furness, Withy and Co., Ltd., at the recent annual meeting. The final dividend of 1% on the ordinary share capital was the lowest this company had paid for forty years. It is a reflection of these depressing times, and indicates that the improvement hoped for is still delayed.

Lord Essendon stated that against a tonnage carrying increase of more than 50% in excess of the comparative figure in 1913, it was estimated that the world's sea-borne trade was about half what it was in 1913. British tonnage, which had increased from 18,270,000 gross tons in 1913 to 18,600,000 in 1933, was approximately 28% of the whole, and we were carrying about 40% of the world's trade. We had a lower percentage of laid-up tonnage—viz., 16%—than any other country, with the exception of Japan, Sweden, and Denmark. The root of the trouble lay in the serious contraction of international trade. They could only look to the leaders of governments and those in control of political, economic, and financial affairs to establish the foundations upon which international trade might be resuscitated.

Schemes for Harnessing the Danube

Plans are being prepared by engineers of Yugo-Slavia and Rumania for harnessing the waters of the Danube. The schemes contemplated provide for two powerful generating stations, capable of generating the equivalent of about 750,000 h.p. The site of the proposed works would be at Orsova, where the river passes through the crags known as the iron gates, at its narrowest and swiftest. Locks would be built which would enable vessels of very much greater tonnage than is at present possible to pass up the Danube. Should these plans be adopted by the Rumanian and Yugo-Slavian Governments, an opportunity will certainly be provided for British contractors who have successfully carried out the work involved in similar enterprises of this character. The cost of the proposed scheme is estimated at £7,000,000.

International Control of Tin Production

The report of the Sub-Committee on Tin states that discussion of the existing international scheme of control did not elicit any substantial criticisms of the scheme, and no alternative methods of control were proposed. It considers the scheme is framed on sound lines, and that it has been largely successful in achieving its main objectives. The Sub-Committee is satisfied, from statements made by the Chairman of the International Committee, that the Committee is fully aware of the undesirability of permitting prices to rise unduly, and that the signatory Governments are also in accord with this point. Moreover, it is in the interest of the producing countries to increase their production quotas whenever the situation permits.

The opinion is expressed by the Sub-Committee that all the countries which now produce the metal in appreciable quantities and are not at present participating in the control scheme should be asked to enter into negotiations with the International Tin Committee in order to secure, if possible, their adhesion to the scheme on the basis of a flat rate quota fixed with due regard to the special circumstances of each country. It is suggested that in determining the initial flat rate the basis of negotiation should normally be the level of production in 1932 ; that provision should be made for the increase of the original flat rate from time to time ; and that a standard tonnage should be fixed for each country. Great importance is placed upon early action, in view of the fact that any new agreement must be arrived at before the close of the current year.

New Zinc Plant in North Caucasus

The electrolytic zinc plant which is under construction at Ordzhonikdze (formerly Vladikavkaz), North Caucasus, is to be completed this year. It will be the second biggest plant of its kind in the U.S.S.R. It is designed for an annual output capacity of 35,000 tons of zinc, 12,000 tons of lead, and 46,000 tons of sulphuric acid.

The first unit has been put into operation and it is estimated that production of zinc for this year will be 5,000 tons.

Improved Outlook of Zinc Corporation

While development work had again been severely restricted, it might be confidently stated that the mine had never looked or promised better than it did to-day, said the Right Hon Sir Robert Horne, M.P., the chairman of the Zinc Corporation, Ltd., at the twenty-second ordinary general meeting held recently. Costs between 1928 and 1932 had dropped by over 8s., Australian currency, per ton, and since the end of 1932 a further improvement had been effected. In part that was due to increased output, but more efficient methods and rigid economies had played a large part. Costs must be expected to vary, and if there was a general rise in price levels, the downward movement in expenses could not continue indefinitely.

They had faced the crisis with a definite programme, and while their financial position in the first two years of the crisis had certainly deteriorated to some extent, it had been steadily retrieved and solidly reinstated at a safe level upon which there was every reason to believe they would be able to maintain themselves. In the next two years, if their work were uninterrupted, over and above expenses in mining and milling they would spend probably £150,000, of which approximately £60,000 would be on development and £90,000 on plant. The net result would be greater efficiency at relatively lower costs and the ability to increase production.

Obituary.

The many friends of Mr. John Rolland will regret to learn of his death, at his residence in London, on July 27. As consulting engineer and representative in this country of Fried. Krupp Grusonwerk A.G., Magdeburg, and the Lurgigesellschaft fuer Waermetechnik, Frankfurt (a branch of the Metallgesellschaft), etc., he had a wide circle of friends. A fluent linguist in German, Italian, and French, besides his native tongue, these accomplishments proved very useful to him in his very interesting and varied career. He started a successful business on his own account in 1921 as consulting engineer and representative in Great Britain and Ireland of Benno Schilde Maschinenbau A.G., Hersfeld, subsequently taking up the agencies of the Lurgigesellschaft and Krupp Grusonwerk.

Catalogues and other Publications

Those who are searching for a rapid machining steel with free-cutting properties, should secure an illuminating brochure recently issued by The United Steel Companies, Ltd. It deals with the standardised rapid machining steel, known as the " Phœnix " brand, and is manufactured by Steel, Peech and Tozer, a branch of the above company. It is claimed that this steel is capable of being machined at the very highest speeds with a silky finish, causing minimum tool wear, and at the same time, is consistent and uniform, is capable of being forged, is tough and resists fatigue comparable with mild steel.

A useful booklet has been issued by the English Steel Corporation Limited, Vickers Works, Sheffield, which deals with this firm's heat-resisting steels and alloysin, cluding several grzdes of " Immaculate " steels and Pyrista and Vickro. It should be noted that these steels and alloys are being used in industrial processes where temperatures of 700° C. to 1150° C. are reached, either intermittently or continuously. Much technical information relating to these materials is given, and the booklet is admirably prepared in conformity with booklets previously issued by this corporation, and relating to other qualities of products.

The Lea Recorder Co., Ltd., Recorder House, Cornbrook, Park Road, Manchester 15, has sent us a brochure describing new " Romer Lea " chain-operated meters for measuring coal or other materials in pipes or chutes. These meters are invaluable in the measurement of coal for boilers, mechanical stokers, pulverisers, etc.

A new publication, issued by The Butler Machine Tool Co., Ltd., Victoria Ironworks, Halifax, describes this firm's 8-in., 10-in. and 12-in. stroke high-production slotters. In addition to standard machines, reference is made to patent tilting body slotters and new precision toolroom slotters designed and built by this firm. A copy of this publication is available on request.

An informative booklet has recently been issued by Samuel Fox and Co., Ltd., of Stocksbridge Works, near Sheffield, a company asssociated with The United Steel Companies Ltd. It describes the process of surface hardening of steel by nitrogen, and gives information regarding the application of a steel hardened in this manner. This company supply steel for treatment under the Nitralloy patents, about which technical data is also given in this booklet.

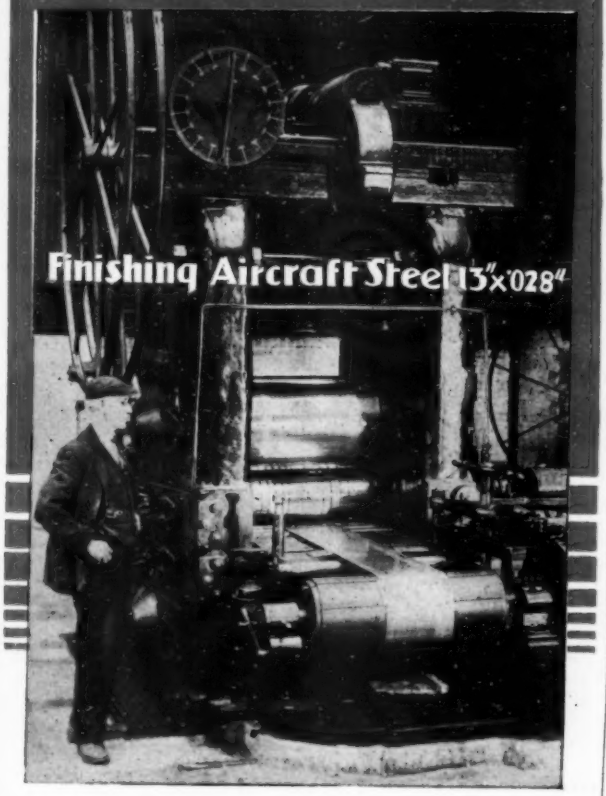
The British Aluminium Co., Ltd., has recently issued a second edition of the glossary of technical terms in English, German and French arranged in rough alphabetical order of the German terms. This edition has been carefully corrected and enlarged and extended to include Italian, and also is indexed under all the languages. This issue is exceedingly useful, and a copy is available on application to The Intelligence Department, Adelaide House, King William Street, London, E.C. 4.

The " Sulzer Technical Review," No. 2, contains an article on the Sulzer high-pressure boiler plant lately installed in the new electricity works at Belgrade. Further articles concern the adaptability of fans for various conditions of service ; the engines for the M.S. *Prince Baudouin*, of the Ostend-Dover express service ; while other sections deal with a variety of orders.

The manufacture and physical properties of nickel-copper-chromium austenitic cast irons is the subject of a technical brochure published by the Bureau of Information on Nickel, Thames House, Millbank, London, S.W. 1. The purpose of this publication is to give more detailed information on " Ni-Resist," particularly on its manufacture and fabrication.

We have received an interesting booklet from G. D. Peters and Co., Ltd., Windsor Works, Slough, which gives information on the wide range of standard welding machines they manufacture. Attention is directed particularly to portable models originally designed for use on the Iraq pipe-line. It is of interest to note that this company are building further models for use in the Persian oil-fields. The booklet describes this company's latest " Plastic Arc " welding machines, equipment, and " Colour Tipt " electrodes.

STRIP STEEL and SHEETS



J. J. HABERSHON & SONS LTD
HOLMES MILLS, ROTHERHAM.

Specialists in Rolling and Heat-Treatment of Aircraft Strip and Sheets.
Range of sizes for all purposes :—
width——————up to 33"
thickness—down to .0015

1829

ELECTRIC, GAS, & OIL FIRED FURNACE TEMPERATURE CONTROL

The difference between manual temperature regulation on the basis of an indicated or recorded furnace temperature and AUTOMATIC temperature regulation, in terms of fuel economy and product perfection, is enormous. A fuel consumption reduction of the order of 20% is common, particularly with town's gas-fired furnaces when controlled by Electroflo equipment, whilst the accuracy of control is guaranteed to within 0.5% at the point of temperature measurement.

The Electroflo Control Pyrometer is superior to all others by reason of its "knife-edge" method of temperature selection, its simple, ingenious control mechanism, and the reliable auxiliary—fully adjustable — equipment employed on fuel-fired furnaces, which constantly maintains the desired furnace atmosphere and best fuel-air ratio. Full particulars free on request.

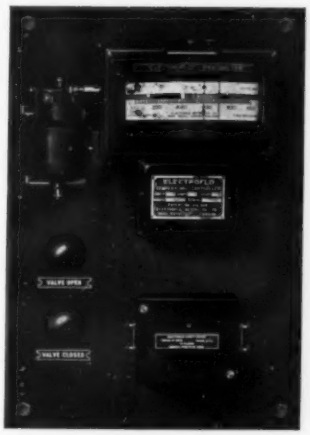
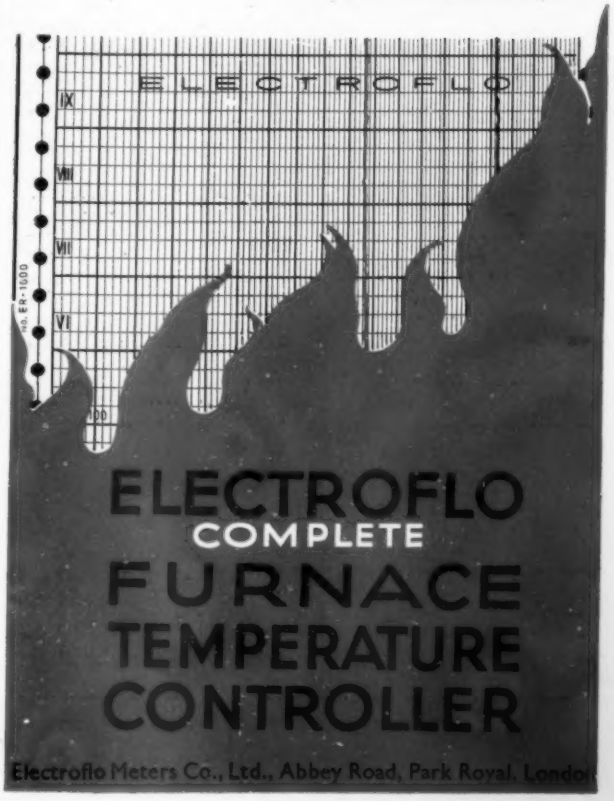


Illustration shows an Electroflo panel mounted Control Pyrometer with pilot lights and patented broken thermocouple safety device, protecting the furnace and its charge in the event of the accidental destruction of the sensitive element.



MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£37 10 0 to £40	0	0
Chinese	27	10	0
Crude	—		

BRASS.

Solid Drawn Tubes	lb.	9¼d.
Brazed Tubes	„	11¼d.
Rods Drawn	„	8⅞d.
Wire	„	8d.
*Extruded Brass Bars	„	4½d.

COPPER.

Standard Cash	£36	0	0
Electrolytic	40	10	0
Best Selected	40	0	0
Tough	39	0	0
Sheets	68	0	0
Wire Bars	41	0	0
Ingot Bars	41	0	0
Solid Drawn Tubes	lb.	10½d.	
Brazed Tubes	„	10½d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	2	0
‡Ferro Tungsten	„	0	1	9
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL: 2–4% Carbon, scale 12/– per unit	ton	29	0	0
NOMINAL: 4–6% Carbon, scale 7/– per unit	„	21	17	6
NOMINAL: 6–8% Carbon, scale 7/– per unit	„	20	17	6
NOMINAL: 8–10% Carbon, scale 7/– per unit	„	19	17	6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	31	0	0
Guar. max. 1% Carbon, scale 13/6 per unit	„	35	2	6
§Guar. max. 0·7% Carbon, scale 15/– per unit	„	39	5	0
‡Manganese Metal 96–98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	8
§ Ferro-Vanadium 25–50%	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/– per unit	ton	5	2	6
20/30% basis 25%, scale 3/6 per unit	„	7	17	6
45/50% basis 45%, scale 5/– per unit	„	11	17	6
70/80% basis 75%, scale 7/– per unit	„	18	10	0
90/95% basis 90%, scale 10/– per unit	„	30	0	0
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	14	17	6
§ Ferro - Carbon Titanium, 15/18% Ti	lb.	0	0	6
Ferro Phosphorus, 20–25%	ton	15	18	0
§ Ferro-Molybdenum, Molyte	lb.	0	5	6
§ Calcium Molybdate	„	0	5	4

FUELS.

Foundry Coke—						
S. Wales	£1	0	0 to	1	2	6
Scotland	—			1	8	0
Durham	1	1	0 to	1	5	0
Furnace Coke—						
Scotland	—			1	5	6
S. Wales	—			0	15	6
Durham	0	13	0 to	0	13	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£55	0	0
*Commercial Ingots	45	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 9
*Cored Bars	„	0	0 11

LEAD.

Soft Foreign	£12	5	0
English	14	10	0

MANUFACTURED IRON.

Scotland—				
Crown Bars, Best	£10	5	0	
N.E. Coast—				
Rivets	10	15	0	
Best Bars	10	5	0	
Common Bars	9	5	0	
Lancashire—				
Crown Bars	9	0	0	
Hoops	£10 10 0 to	12	0	0
Midlands—				
Crown Bars	£8 0 0 to	9	0	0
Marked Bars		12	0	0
Unmarked Bars		—		
Nut and Bolt Bars	£6 15 0 to	7	10	0
Gas Strip		10	12	6
S. Yorks —				
Best Bars		10	15	0
Hoops	£10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, " Tank " brand, 1 in. dia. and upwards—Solid	lb.	8d.
*Cored Bars	„	10d.
†Strip	„	10½d.
†Sheet to 10 W.G.	„	11d.
†Wire	„	1/0⅝
†Rods	„	11d.
†Tubes	„	1/4
†Castings	„	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	6	0
Foundry No. 1	3	7	6
„ No. 3	3	5	0
N.E. Coast—			
Hematite No. 1	2	19	6
Foundry No. 1	3	5	0
„ No. 3	3	2	6
„ No. 4	3	1	6
Silicon Iron	3	5	0
Forge	3	1	6
Midlands—			
N. Staffs Forge No. 4	3	1	0
„ Foundry No. 3	3	6	0
Northants—			
Foundry No. 1	3	5	6
Forge No. 4	2	17	6
Foundry No. 3	3	2	6
Derbyshire Forge	2	19	0
„ Foundry No. 1	3	6	0
„ Foundry No. 3	3	3	6
West Coast Hematite	3	6	0
East „ „ No. 1	3	0	0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 18–16 to £1 approximately.

Pig Iron	Kr. 90
Billets	Kr. 230-290 £12 13 4–£16 0 0
Wire Rods	Kr. 265-320 £14 12 6–£17 12 6
Rolled Bars (dead soft)	Kr. 185-210 £10 4 0–£11 11 0
Rolled Charcoal Iron Bars	Kr. 290 16 0 0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£31	0	0
„ Braziery	28	0	0
„ Wire	—		
Brass	20	0	0
Gun Metal	26	0	0
Zinc	12	0	0
Aluminium Cuttings	74	0	0
Lead	12	10	0
Heavy Steel—			
S. Wales	2	5	0
Scotland	1	19	0
Cleveland	2	2	0
Cast Iron—			
Midlands	1	17	6
S. Wales	2	3	0
Cleveland	1	19	0
Steel Turnings—			
Cleveland	1	11	6
Midlands	1	5	0
Cast Iron Borings—			
Cleveland	1	2	0
Scotland	1	13	0

SPELTER.

G.O.B. Official	—		
Hard	£15	5	0
English	18	10	0
India	16	15	0
Re-melted	18	0	0

STEEL.

Ship, Bridge, and Tank Plates			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	9	0	0
„ „ (Marine) „	—		
„ „ (Land), N.E. Coast	10	0	0
„ „ (Marine) „	10	10	0
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails	£8 10 0 to	8	15	0
Sheffield—				
Siemens Acid Billets	9	2	6	
Hard Basic	£8 2 6 and	8	12	6
Medium Basic	£6 12 6 and	7	2	6
Soft Basic		6	0	0
Hoops	£9 10 0 to	9	15	0
Manchester				
Hoops	£9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.		10	5	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/–
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ¼ in. to ½ in.	„	3d.
Under ¼ in. to ⅛ in.	„	1/–
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/–

TIN.

Standard Cash	£214	10	0
English	215	10	0
Australian	223	0	0
Eastern	216	10	0
Tin Plates I.C. 20 × 14 box	0	17	3

ZINC.

English Sheets	£26	0	0
Rods	30	0	0
Battery Plates	—		
Boiler Plates	25	5	0

* McKechnie Brothers, Ltd., quoted Aug. 12. † C. Clifford & Son, Ltd., quoted Aug. 12. ‡ Murex Limited, quoted Aug. 12.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices quoted Aug. 12, ex warehouse.